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—AND—
Allied Branches of Study.

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THE AMERICAN

Meteorological Journal.

VOL. I. DETROIT, MAY, 1884. NO. 1.

EDITORIAL NOTES.

WE herewith tender to those interested in meteorology the first number of an American journal devoted to that subject. The encouragement and assistance we have received from all parts of the country indicate that the idea that such a journal was needed was not a misapprehension. We let this number speak for itself. In the June number we expect to be able to provide as important a table of contents as in this. In the next number Professor W. M. Davis will treat of the winds and currents of the equatorial Atlantic, with several illustrations. Dr. A. J. Phinney will give an account of the remarkable double tornado which destroyed Oakville, Ind., with a chart showing the destruction in the village. Dr. H. A. Hazen will give the results of his experiments with the thermometers *frondes*—a novel and interesting use of this familiar instrument. Professor S. R. Thompson will discuss the rainfall observations in Nebraska from the earliest records to recent date and illustrate the change taking place in the precipitation in that state. We also expect to insert a translation of H. Schwirkus' study of the aneroid barometer from the *Zeitschrift für Instrumentenkunde*, in which the author points out the changes necessary to make the aneroid an efficient instrument. We will also translate the notes on arched squalls in a recent number of the *Comptes rendus*.

In an early number will be begun a series of studies on the levees of the United States, where they are and where they ought to be, with some account of the territory subject to overflow by their breakage. We also hope to have a series of original articles on tornadoes from the pen of a competent foreign student, and in due course of time we expect to print a translation of a Mexican memoir, viz:—Senor Covarrubias' study of the effects of the sun's heat in dilating the earth's superficies. We give these lists (subject to change) as an indication of the ground this journal will try to occupy, but we hope that our apparent fullness of matter will not prevent meteorologists from sending us contributions. We have already learned that this small journal has a large capacity for the absorption of manuscript. The editor does not consider himself in any sense a censor, and his acceptance of contributions will be guided only by his judgment as to their suitability to the general purpose of the journal.

HAS not the time arrived when an American meteorological society should be established? Such societies have already been established in several countries, and some of them have already attained considerable age. In every case they have been found to serve a useful purpose, though to very different degrees. In this country meteorological interests are very large and the popular interest in the science is general. A large amount of time and money is annually expended on the science by the nation, several states and many individuals. A meteorological society would tend co-ordinate and concentrate the energy thus expended, prevent its duplication and misdirection, and guide the popular interest into more intelligent channels. There are two ways in which such a society might be established. Meteorologists might make it a point to go to the Philadelphia meeting of the American Association with the intention of establishing a meteorological sub-section; or they might establish an independent society, there and at that time, or elsewhere on some other date. There are several advantages in either way, and which one should be chosen would depend on whether the society should be of a popular or technical character. We invite correspondence on the subject.

The German Meteorological Society was established last November. By special invitation the leading meteorologists assembled at Hamburg and formed the organization. Twenty-two were present

and the invitations do not seem to have included many more. A general invitation, however, is issued for a meeting at the same time and place as the meeting of the general German scientific society, viz: September, 1884, at Magdeburg—where the organization will be completed. The society is to fill its own ranks, after careful scrutiny of applicants. It is to have patrons (those who pay at one time $75 or upwards) and honorary, ordinary and corresponding members. The yearly fee for ordinary members is $2.50, with some specified exceptions. A journal is to be established and branches organzied. The seat of the society is to be determined every three years. All but corresponding members are to receive its publications free. No permanent library is to be established, but books presented are to go to the reviewers or be sold to certain libraries under specified conditions. Annual meetings are to be held in connection with those of the general society (Die Versammlung Deutscher Naturforscher und Aerzte). The council will practically have complete management of the society and consists of sixteen members, including the six officers. It is consequently a nomad society, with a printing press but no books among its baggage, and will thus differ fundamentally from the most successful meteorological societies established heretofore; but the eminent names among its charter-members are sufficient warrant that the form of the society has been wisely adapted to the wants it is to supply.

THE meteorological bearings of the contribution on the Huron River may not be apparent at first sight. This river drains the valley in which Ann Arbor lies. Over this valley the annual precipitation is from 36 to 40 inches. The question arises, what becomes of this water? Professor Davis contributes to the answer of this question in so far as he shows that, at the most, only ten or twelve percentum is carried off by the river. The remainder must be disposed of by evaporation, by physiological action, and by underground disposal. The last is the factor incapable of direct measurement, and determinable only by the elimination of the other three. The practical question is, whether the underground, but not deep, supply of water is so large that it can be depended on for city water-works, and this question has been solved in the affirmative for several cities in Michigan.

There are several curious questions connected with the supply of water for wells in the vicinity of the great lakes. It is a popular

belief, at least in the states adjoining the upper lakes, that high water in wells is propagated from the lakes southward, though slowly and at irregular intervals. Another popular belief is that in the prairie region there are sometimes underground ponds of considerable size and within the reach of the deeper wells. These notions have a direct relation to the problem of local water-supply but, so far as known to us, they have never received any scientific attention.

SOME one should now invent some mechanical and continuous register of cloudiness. The present eye-estimates are unsatisfactory and when we get ready to make up the earth's accounts of receipts and expenditures of heat, we must have some more trustworthy record of cloudiness. The sunlight-recorder sometimes employed is defective in that it registers only direct sunlight and gives no indications of clouds at night, or even daylight clouds which do not directly intercept the sun's rays. It bears about the same relations to the nephelometer which we should have, that the sun-dial bears to the clock. There is a notable difference in the radiation to clear sky and clouds, and this must be capable, in some way, of instrumental measurement and record.

IT makes us envious to learn that they have had an unusually mild winter in France. A charming *feuilleton* of the Paris *Journal des Débats* of some weeks ago gives an interesting list of mild winters in Paris for the present century. They were, (naming them by the year in which they began), 1883, 1877, 1871, 1869, 1866, 1862, 1858, 1855, 1852, 1850, 1848, 1845, 1842, 1838, 1834, 1831, 1827, 1824, 1821, 1818, 1816. The warmest for two centuries was that of 1709, and the next, 1876. It is noted that in 1831 and 1821 there were phenomena of sunglows as in 1883. In 1831 there was a violent volcanic eruption in the Sicilian seas, with the formation of a new island. Earthquakes and volcanic eruptions coincide with about a third of the other warm seasons. We are curious to know with what proportion of the cold seasons there were earthquakes and eruptions, but on this the *feuilletonist* is silent. Whatever may have been the effect in France, the northern American states were not favored with an especially mild winter.

CURRENT NOTES.

According to the daily press Lieut. Gordon, of the Canadian Meteorological Bureau, is organizing a system of railway weather signals by means of disks for the benefit of farmers.

Great efforts are being made to establish a series of posts for meteorological observation in the China seas. There ought to be little difficulty now in accomplishing it, as the three great Powers in the Far East—England, China and Japan—not to speak of France, have now maritime interests sufficient to justify a larger expenditure than is likely to be demanded. It is not generally known that several attempts have there been made in this direction already, and with beneficial results.

The Boswell Observatory (so named in honor of the donor) is starting out with a good equipment at Crete, Nebraska. It is connected with Doane College and is in charge of Professor Swezey. In addition to its astronomical outfit, including an 8-inch equatorial, it has a set of meteorological instruments, among which is an anemograph.

The translation of M. Hirn's description of his actinometer in the *Comptes rendus* will probably prove interesting to a large number of readers. It is called by its inventor an *Actinomètre totaliseur absolu*, and a friend suggests that the best English expression for *totaliseur* is integrating, making the English name the absolute integrating actinometer. The instrument seems to combine the requirements of accuracy, ease of management, and convenience of reading, and it is besides so inexpensive as to be within the reach of anyone wishing to pursue the important study of solar heat-radiations.

Losses by the elements in France are estimated as follows by M. Radau: Fire, hail, frost, storms and inundations cause a loss of from forty to eighty millions of dollars annually. The losses from the death of stock and from fires recur with some regularity and amount to six or eight millions. On the other hand the destructive action of the atmosphere is capricious; from 1873 to 1877 the total losses by hail varied from upwards of nine to more than thirty millions of dollars; that of frost from three to nearly fifty millions; inundations, one to thirty millions. These figures will give at least an idea of the relative importance of these scourges. For the same time the average for marine casualties is 280 annually, and in one case out of two the ships are lost. The material damage is from four to six millions of dollars. For the entire world the marine loss is about ten times as great, and it is safe to say that, on the average, one or two ships in every hundred are lost annually.

What follows is an extract from the log of the American ship "Sea Witch," which we owe to Captain R. K. Clarke, master of the vessel. The extract is unchanged, except that the abbreviations and ellipses, usual in a ship's log, are supplied so far as may be necessary to prevent ambiguity.

Aug. 27th, 1883. Ashore on the Bar of Surabaia, Java; sounds of heavy *cannonading;* we supposed it was some salute. The barometer was unsteady, sun dim and smoky. On the 29th learned of the eruption of Krakatoa. On passing Krakatoa on the 31st could not see it—sky and atmosphere were full of smoke.

Dec. 27th. With weather N. and E. N. E, observed large masses of ashes and pumice stone, looking like large shoals. At 8 P. M. we were passing through

large fields, some of which were two miles in extent. Depth of pumice stone and ashes two feet. Shortened sail till daylight, when we made all sail; 10 A. M., had Merak Island abeam. Sea with streaks of stone of all colors and ashes. At 12 we passed Anger; still fields of ashes, etc.

Dec. 28th, 4 P. M. We had Krakatoa Island W. N. W., 6 miles distant; continual streaks of ashes and pumice stone; ship going through them grating as if on a sand-bar; 29th, less pumice and ashes; 29th, could see no more; wind fresh, weather fine.

Dec. 31st. Lat. 11 deg. 24 min. S., Long. 100 deg. 21 min. E.; squall, unsteady, rain and gloomy; began passing through masses of ashes and stone.

Jan. 4th, 1884. Passed the last streak at 6 A. M. Lat. 18 deg. 24 min. S., Long. 88 deg. E.

To this Capt. Clarke, adds: "This is from my private log-book. * * * What strikes me as peculiar is, how did this matter get 1000 miles west of Java? You will say, 'currents;' but the N. W. monsoon begins in Oct. and the current sets east. But, again, the N. W. monsoon did not get to Java this year; that is, up to the time I came by. You, of course, can imagine the change from the eruption. No one would know the coast from Java Head to St. Nicholas Point."

The San Franciscans, contrary to the general tendency to magnify local phenomena, are not disposed to admit that their earthquake of March 25th was more than a light shock. A friend in that city writes us, betraying, between his usually gentle lines, considerable indignation at the lively imagination of the "Ass. Press agent" at that point. It is admitted, however, that the shock was the heaviest they have had since 1868, but it only cracked a few walls and set furniture to rocking. The heavy thunderstorm with vivid lightning, which occurred soon after, is not generally mentioned.

Apropos of the earthquake, we add the following as a contribution to the means of estimating the probable reliability of newspaper meteorology. It is clipped from the San Francisco *Evening Post* of April 4th.

The following sensational dispatch appeared in the New York *Telegram* of March 26th:

SAN FRANCISCO EARTHQUAKES—FIFTY BUILDINGS IN RUINS—LOSS OF LIFE FEARED.

[Special Dispatch to the Evening Telegram.]

SAN FRANCISCO, CAL., March 26th.—Shortly before five o'clock this morning this city was visited by the heaviest earthquake known here since 1868. It lasted fully twenty seconds, and occurring at the hour it did caught people napping, so when they were suddenly awakened by the shock they thought the millennium had come, and immediatly there was great consternation. People rushed out of their houses wild with excitement. Before the first shock had scarcely spent its force, the streets were filled with hundreds of half dressed, frightened and nearly half crazed men, women and children. In the Chinese quarter the scene baffled description. The Mongolians, however, appeared in full dress compared with the white people. In that portion of the city where the shock was the heaviest the Chinese seldom undress. Along the water some fifty houses built on made ground are in partial ruins. No loss of life has as yet been reported, but it is more than probable that there has been some person buried in the ruins of the fallen buildings. A second and lighter shock occurred at twenty minutes past five, and was followed at half past five by a still lighter one, and rumblings are heard continually.

The average San Francisco reader will wonder what sort of an inspired liar could have sent such a dispatch from this city; but the truth is it never went over the wires. The earthquake referred to, it will be remembered, occurred in the afternoon at about the hours named. In all probability a dispatch something like this was sent:

"Severest earthquake in years to-day just before five. Great damage probably done. No loss of life. A lighter shock at 5:20."

And the able editor, guessing that it was "A. M." instead of "P. M.," kindly furnished the details about people in their nightshirts out of his own head. A man will make a mistake sometimes.

The following circular bears a title "Foreign and Colonial Rainfall Returns," and reached us from the British Legation at Washington through the Chief Signal Office. We commend it to the favorable consideration of our readers:

Wanted for the purpose of a scientific enquiry into the amount and fluctuation of the rainfall in different parts of the world, long and continuous records of rainfall extending from as early a date as possible.

The records should state the annual falls only, as taken year by year without a break, for periods of at least fifteen years; but the longest possible period is most desired. The name of the place of observation with, if possible, the latitude and longitude, and its elevation above the sea level. The total annual fall should be expressed in millimetres, English inches, or local or obsolete measures; but if in either of the latter their equivalent in millimetres, or English inches, should be given. The name of the observer, or authority, or publication from which the record is obtained should be given. The records should be from observations made at a single station, and should not be compiled from the records of two stations, but the greatest number of different records taken at different stations is desirable to avoid local errors or peculiarities. Any information on the subject will be thankfully received by A. R. BINNIE, M. Inst. C.E., F. R. Met. Soc., F.G.S., addressed Town Hall, Bradford, Yorkshire, England, and in return contributors will be furnished with a copy of the result of the enquiry.

The American Ornithologists' Union has undertaken a study of the migrations of birds, and desires the co-operation of all able to assist it. The plan includes some meteorological data and such others as the dates of the flowering of plants, the leafing and falling of leaves of various trees and shrubs, dates of breaking up and disappearance of ice in rivers and lakes in spring and freezing over of the same in fall. A printed circular gives these wants in more detail, and can be obtained of C. HART MERRIAM, M. D., Chairman of Committee on Migration, Locust Grove, Lewis County, New York.

Four series of storms of tornadic character have passed over the states east of the Mississippi River since the beginning of the year. For the first and the second series we have the advantage of the sets of maps, four in each set, which were made by Sergeant Finley as a preliminary study of the storms and published by the Signal Service. The maps are in attractive form and full of information, and are to be followed by the results of a more detailed study. For the other series we have had to depend on the newspapers and private correspondence.

I. The first series occurred February 19th, and the tornadic storms were twenty-seven in number. One storm occurred in Missouri; five along the Ohio River from Cairo to near Cincinnati; three in central southern Kentucky and the adjacent part of Tennessee, north of, and, in a general way, in a line parallel to, the Cumberland River. All the others were in a band stretching from Starkville, Miss., to near the mouth of the James River in Virginia. The tornadoes were on the south side, or rather in the southeast quadrant, of an area of low pressure, the center of which was 800 or 1000 miles away, and passed during the day from near Keokuk to Georgian Bay. A characteristic feature of the isobars surrounding the center is a trough-shaped depression extending southward nearly to the Gulf of Mexico. Except the solitary Missouri one, the storms are in three bands running northeast and southwest. The loss of property was three or four millions of dollars and of lives about one thousand with perhaps twice as many more wounded. Ten thousand buildings were destroyed and fifteen or twenty thousand people made homeless.

II. The second series occurred March 11th and were eight in number, one in southern Illinois on the Ohio River, one in Central Kentucky, the rest in Mississippi and Alabama. These storms were also in the southeast quadrant of the storm area, of which a trough-shaped prolongation extended southward. The center of the storm-area was also in this case distant several hundreds of miles and passed during the day from northern Iowa to the north of Lake Superior. In this and the preceding series the maps show plainly a relation between the storms and the thermometric, rather than barometric, gradients. For this series the loss was smaller—five lives and about a third of a million in property. From the newspapers we are able to add one to this series of storms, making the number nine. The last occurred in Saline Co., Missouri.

III. The third series occurred on March 25th. The information we have concerning it is derived from the newspapers and from private correspondence. Among our correspondents we are especially indebted to F. M. Williams, editor of Newton, (N. C.) *Enterprise*, Rev. Dr. T. W. Humes, late chancellor of the University of Tennessee, Professor John W. Glenn of that institution, E. Kirkwood, Manzy, Indiana, and others. The storms were quite numerous and extended over a territory from Indiana and Alabama to eastern North Carolina. An especially severe tornado passed over the Kentucky bluegrass region, and northern Georgia and North Carolina suffered extensively. There was considerable loss of life and great destruction of property. The following is from a letter from Professor E. E. Barnard and gives some interesting facts concerning the storms of this series at Nashville:

"The storm referred to came up from the northwest (slightly more west) between 7^h and 8^h A. M. of the 25th March. I noticed, what appeared to me at the time as very remarkable, that the principal storm came, as above stated, from a direction a little west of northwest. This consisted of a heavy, low flying dark not black) storm cloud with ragged trailings, marking the rear or following outline; most of these trailings hung very low. The storm cloud seemed to move with remarkable velocity; rushing diagonally toward this from the south—slightly west—was apparently another storm, or at least heavy, dark, swiftly flying clouds; from an easterly direction a similar rushing of the clouds was noticeable. The storm from the northwest, the dark clouds from the south, and those from the east all driving fiercely to a common point, which would be at an alt. of some 60° toward the southwest. Glancing toward that point as the storm of hail and rain struck us, I noticed that the clouds everywhere near the direction indicated were *stationary* as if their velocity had been destroyed by a mutual collission. The rain was the fiercest and heaviest I remember to have ever seen. It seemed as if the whole heavens would fall; almost at once the hail fell with a deafening clatter. Rain and hail falling together for, I should judge, well on to a quarter of an hour; the hail then ceased, but the rain continued with unremitting intensity for a considerable time. All this was accompanied by a terrific wind. I ran out several times in the storm and collected some of the stones. They were mostly of one size; that is, they were all large—about 0.5 in. in diameter—but they were considerably flattened, the thickness being about $\frac{1}{2}$ the diameter. Their surface was very uneven, and in the centre of each one was a whitish ball of snowy looking matter nearly $\frac{1}{4}$ inch in diameter; the stone otherwise was transparent ice. During the bombardment the Fahrenheit thermometer outside stood at 58.6 at 8^h A. M. Frequent heavy rains and high wind the rest of day, clearing in evening."

Some facts concerning the Gainesville (Ga.) storm are given in the following cutting from the Atlanta *Constitution*, for a copy of which we are indebted to the

Rev. Wm. Clay Wilkes, President of the Georgia Baptist Seminary at that place. Mr. Wilkes' residence was completely destroyed by the storm:

* * * "There is a vast difference of opinion as to the shape of the moving danger, some asserting that it was in the shape of a boiling chaldron of pitchy blackness, foaming and seething like the smoke of a "coal burner," while many confirm me in my opinion. I only got a farewell view of it as it passed the corner of a row of brick buildings, and was lost to sight but not to memory, and as to myself I stick to my original proposition that it was funnel-shaped. It looked like a cone with the vertex downwards the moments it was in sight and travelled like a corkscrew round and round boring with its point. It was not nearer the ground than sixty feet when it was seen by me, travelling apparently at the rate of sixty miles an hour and roaring like heavy rolling thunder. Numbers say they witnessed its formation, that a cloud was travelling southwest and a smaller one travelling from an opposite direction, that they met and united and began to boil and roll like a dense smoke, stationary as if undecided as to its course, finally following the course of the smaller cloud, and snatching clouds as it came with a tilt in the direction of Gainesville. It came into Hall county from Forsyth county, crossing the river just below the confluence of the Chestatee and Chattahoochee rivers, going out near Lula in the edge of Banks. The river where it crossed is about 100 yards wide, and it is said that it was a bottom-wiper, taking nearly all the water out of the river. * * * Here it displayed wonderful freaks and leaves a problem for scientists to solve. It came with a push and a suck; an instance: it pushed the door open breaking the stop off of the facing and sucked a door out breaking the stop in the same manner. It also sucked a piece of sheet iron partly up the chimney. * * * The velocity of the cyclone was about sixty miles an hour, and its course a little north of east. The force of the cyclone must have been fifty pounds to the square foot. It is thought that the cyclone passed a given point in less than a minute—that is, the main current—then the leaves, mud and water lasted about a minute following in its wake. A person not familiar with Gainesville, were he to come here would think this a great mining country. Storm pits are being dug by wholesale."

IV. The fourth series fell on the evening and night of April 1st and the morning of the 2nd. There were, as in the first and second, two apparently separate sets of storms. The first stretched from Indiana to central Pennsylvania, the second from Alabama to South Carolina. The northern was the more severe, and Oakville, Ind., was swept out of existence.

Thus a row of southern states, not considered especially subject to tornadoes, has been already visited four times this year. None of the storms seem to have been within two hundred miles of the Gulf. The series have shown a decided tendency to advance northward, as might be expected from the northern summer migration of the tracks of storm-centers.

Tornado risks are usually written to include "cyclones and wind-storms," so that unfortunately we will not be able to get a decision by a jury as to the distinction between tornadoes and windstorms as we have been so fortunate as to do in the contested subject of the relations of tornadoes and electricity. We owe to the Superintendent of the Kansas Insurance Department a statement of fire and tornado underwriting in that state, from which we glean the following: Six companies wrote $6,781,099 in tornado risks during the year and received $112,636 in premiums. Several companies wrote combined fire and tornado risks and were unable to separate them for report. The losses are combined, and it is impossible to tell what part is due to tornadoes and what to fire.

From the Actuary of the Missouri Insurance Department, Mr. Aug. F. Harvey, we have received the following general table and the appended ratios:

Name of Company.	Location.	Risks written.	Premiums thereon.	Losses paid.
Concordia Ins. Co.....	Milwaukee, Wis.	$39,060	$352 58	.....
German	Freeport, Ill....	13,550,840	180,650 00	$23,650 00
German Fire.....	Peoria, Ill.....	96,224	742 60	.....
Glens Falls.....	Glens Falls, N.Y.	2,070,013	17,034 29	1,800 60
Merchants'	Newark, N. J...	21,400	160 90	.....
Merchants'	St. Joseph, Mo..	141,900	1,098 45	.....
Phœnix.....	Hartford, Conn..	845,325	8,054 97	.....
State	Des Moines, Ia..	5,267,579	104,130 20	12,882 77
Washington F. & M...	Hartford, Conn..	168,502	1,771 24	.....
	Total.....	$22,200,843	$313,995 23	$38,333 37
Business by same Co's	done in Missouri,	3,171,028	50,311 56	13,883 37

Average rates of premium (general)..... 1.41+%
" " " (in Missouri)..... 1.59−%
Average loss of amount written (general)..... .17+%
" " " " (in Missouri..... .44−%
" " of premiums (general).....12.21−%
" " " (in Missouri).....27.59+%

An examination of these figures brings into plain view several interesting facts. The total risks by wind-storms (not combined with fire) is twenty-two millions of dollars. This does not include the combined risks. If they amount to as much more, the total tornado insurance would not reach fifty millions in the United States. If we compare this with the value of property liable to loss by tornadoes, it is evident that the business has only fairly begun and is capable of indefinite extension.

Taking the ratio of losses experienced to premiums received, it is evident that the companies have been eminently prudent in this comparatively untried field of underwriting. This is creditable to them and to the interest of the insured, but with increasing experience, we may fairly expect the ratio to be lowered. Again, comparing the general ratios with those for Missouri, it appears that both nature and the companies have discriminated a little against that state.

OHIO METEOROLOGICAL BUREAU.

During a few years past much aid has been rendered to practical meteorology in this country by the organization of State Meteorological Bureaus. In several states efforts are now being made to secure the establishment of Local Weather Services, and for this reason it may be useful to give a brief history of the organization and equipment of one which has been in operation for two years. The Ohio Bureau is by no means regarded as a model by its friends, there being several improvements in its system of working which they hope to see brought about in the near future.

As letters of inquiry are constantly being received by its director, it is believed that such an account as will be here given may serve as both a guide and a warning to those about to undertake the establishment of similar services.

The interest in this subject which had manifested itself for several years took a practical shape in the winter of 1881–82, in urging the General Assembly of the State of Ohio to establish a Meteorological Bureau.

The attention of Gov. Foster being called to the subject, he recommended such action in a special message. The committees on Agriculture in the House and Senate were earnest in their support of the scheme. The State Board of Agriculture considered the subject at one of its meetings, and unanimously recommended the establishment of a Bureau.

Toward the latter part of the session the following bill was introduced:

AN ACT

To establish a Meteorological Bureau for the State of Ohio.

SECTION 1. *Be it enacted by the General Assembly of the State of Ohio*, That there be and hereby is established at the State University at Columbus, Ohio, a central office for meteorological observation, and with the professor of physics of said university, the secretary of the state board of agriculture, and a third person, to be appointed by the governor, as a board of directors; the members of the board of directors shall be commissioned by the governor, and be duly qualified as like officers of the state.

SEC. 2. The professor of physics of said university is hereby appointed president of the board, and by and with the advice of the directors shall establish, if practicable, one volunteer weather station in each congressional district, and supervise the same; he shall receive reports therefrom, and reduce the same to tabular form, and report the same monthly to the state printer for publication of the Ohio weather report, and shall annually make a report to the governor which shall contain a detailed statement of all expenditures made during the year, and a summary of the observations made at the various stations.

SEC. 3. That the supervisor of state printing be directed to print, under the contract with the state printer, 2,000 copies of each monthly report; 1.000 copies shall be distributed by said board, and 1,000 copies shall be delivered to the secretary of state, to be distributed by him in the same manner as other state documents.

SEC. 4. There is hereby appropriated for the ensuing year, for the establishment and maintenance of said bureau, and stations, the sum of $2,000, or so much thereof as may be necessary for the purpose of meeting the actual expenses of carrying out the provisions of this act; no part of said sum shall be paid for salaries of any officer or for office rent, but a reasonable part of the same may be paid for the services of a clerk at the central station.

SEC. 5. No money shall be expended, except upon the order of the president director, by and with the approval of the board.

SEC. 6. This act shall take effect from and after its passage.

This became a law on April 17th, 1882. While in the main the act is satisfactory, it contains one or two defects which were not detected until after its passage, and which may be referred to here, with a view to prevent their repetition in similar enactments. One of the most important is in Section 2—in which there is no provision for the printing of the annual report to the governor. As it now stands this report which ought to be of considerable value, as it contains the meteorological summary of the whole state for the whole year, as well as the financial statement, must lie in the governor's hands in manuscript, or special legislation must be obtained to secure its publication. The latter is not always easy, and it would have been far better to have provided for it in the beginning.

In Section 3 it is provided that 1,000 copies of the monthly report, one-half of the whole number issued, shall be delivered to the Secretary of State, to be distributed by him in the same manner as other state documents. Unfortunately, state documents when distributed in the ordinary way do not always reach those most likely to be interested in them. Experience has shown that while the demand for these reports, through the Bureau itself has been greater than the supply,

of the 1,000 copies delivered to the Secretary of State, but a small number were ever used to any advantage. It would evidently be wiser to distribute nearly if not all of the monthly issue through the Bureau, to which nearly all demands are likely to come.

It will also be observed that in Section 1 there is no time limitation on the service of the directors. This is not necessary in the case of the two ex-officio members of the board. Its omission in the case of the third member appointed by the governor is certainly not regretted as the board is organized at present, in view of the great interest which that member has shown in the work, and the amount of time and labor he has contributed to secure the success of the Bureau.

The Board was organized on May 14th, 1882, as follows:

T. C. MENDENHALL, Professor of Physics, Ohio State University.

W. I. CHAMBERLIN, Secretary of State Board of Agriculture.

GEO. H. TWISS, Esq.

Mr. Newton M. Anderson was elected Clerk and Secretary of the Board.

The following selections from the first "Circular of Information" issued by the Bureau soon after its organization will show something of the scope of its operations, as proposed by the Board of Directors:

The objects sought to be accomplished in the establishment of a State Weather Service are generally understood, and yet to some extent misunderstood. It is not expected, indeed it is not possible to accomplish much in this manner in the way of prediction. In the present condition of meteorological science this can only be accomplished by such means as are at the command of the National Service, including a large number of trained and paid observers, scattered over a very wide area, with the central office armed with the telegraph for the receipt and distribution of information. Extensive as is the system, however, its very magnitude makes it impossible, at least at present, to be as complete as is desired. In the State of Ohio, for instance, reports from three or four stations are quite insufficient to furnish necessary data for a discussion of the meteorology of the whole State. The stations of the United States must be located primarily in view of the interests of commerce upon the rivers, lakes and sea coast. The great interior of the country, therefore, although of equally great importance from a meterological stand-point, cannot be thoroughly studied through the agency of this service alone. The recognition of this fact has led the Chief Signal Officer to urge the establishment of State Weather Services, the information obtained through them being of great value in the discussion of the general meteorological problem. It will thus be seen that the work of the General Government in this direction, the great value of which is now so completely established and admitted, must be greatly aided by a State Service, and in a manner doubtless more systematic and less expensive to the people than if undertaken by the General Government itself.

But results of more immediate value may also be expected. The State of Ohio covers so wide an area that the meteorological conditions of different localities are quite varied. Very considerable differences of temperature, humidity, rain-fall, etc., will be found to exist over its surface; and the influence of these differences, especially upon the growth of crops, fruit, etc., is, of course, very great. Those who are constant readers of the daily papers learn, generally in a vague sort of a way, the conditions of the various parts of the State and country in this respect, but as a rule the farmer knows little of the weather in any locality except his own. A knowledge of what the weather *was* during any month is often of as great value to the agriculturist as a tolerably certain prediction of what it *will be* during the next.

It is intended to furnish information of this kind; and to that end the monthly reports will be made up and issued as soon as possible after the end of the month; and the attempt will be made to distribute these reports as widely as possible. It is believed that when they become to be properly understood, they cannot fail to be of great practical value, not only to those directly engaged in agricultural pursuits, but to all who are directly or indirectly, dependent upon the soil.

The establishment of the State Weather Service has been favored and urged by many physicians, that they might procure the material for a more rational study of the influence of climatic conditions upon many diseases, which are often confined and restricted to certain localities. All reliable meteorological information is of value in this direction, and it is believed that in the future, when an observer is established in every county in the State, great aid will be rendered to those engaged in the investigation of this important point.

As soon as practicable, observers were appointed for each congressional district, and stations were established. It may be stated that no difficulty has been experienced in securing the services of volunteer observers, except that the most suitable person is not always found in the most suitable place.

Each station is provided with the following instruments:

One dry bulb thermometer,
One wet bulb thermometer,
One maximum thermometer,
One minimum thermometer,
One wind vane,
One rain gauge.

The cost of this equipment, including the expense of delivery to the observer, is from $20.00 to $25.00.

Every observer is supplied with all necessary record books, blanks, postage, etc., it being intended to relieve him from all actual expense connected with the work.

The expense of putting up the instruments, the erection of the thermometer shelter, etc., has been generally borne, however, by the observer, assistance having been rendered by the Bureau in a few cases.

Reports are made weekly on postal cards printed in blank furnished for the purpose, and a station summary at the end of each month. There is found to be an advantage in the weekly report in that it will enable the secretary to prepare much of the matter for the monthly report in advance of the receipt of the station monthly summary.

In addition to the instruments named above, a number of barometers have been distributed in accordance with geographical and meteorological considerations, the funds at the disposal of the Board not being sufficient to enable it to supply one to each observer.

A standard barometer was also purchased for the use of the Central Office, and a standard thermometer from the Yale Observatory.

The barometers and thermometers supplied to the stations were purchased of J. & H. J. Green, New York. The cost of barometers was $30.00 each.

The wind vanes were made in Columbus, and the rain gauges were kindly furnished by the Chief of the U. S. Signal Service.

Owing to the unavoidable delay in procuring instruments for use at the stations the work could not be regularly begun before October, 1882, and the report for that month was the first regular monthly report from the Bureau. Since that date they have been issued regularly without interruption.

Mr. Anderson served as secretary until August, 1883, when to the regret of the Board, he tendered his resignation. Mr. E. H. Mark, who had been a station observer at Washington C. H., was elected to fill his place, and he has discharged the arduous duties of the position with great energy and success.

It may be well to remark that all reductions and corrections of observations are made by the Secretary in the Central Office.

Greater uniformity and accuracy are thus secured, and the labor of the volunteer observers is lightened as much as possible. Wherever desired, the tables and constants for correction are supplied, and observers are encouraged to reduce observations, and publish the same in the local newspapers which is being done in many places.

The primary object of the Bureau was the collection and dissemination of information pertaining to meteorology. In the way of dissemination, reports upon special subjects have been now and then published; one of the most important being a paper on lightning protection which was printed in the report for December, 1882. The demands for this paper were so great that the supply was soon exhausted and it was republished in the report for July, 1883.

One of the most important undertakings of the Bureau has been the establishment of a system of railway signals by means of which people in the neighborhood of a railway line could be notified of the weather probabilities of the day in accordance with the predictions received from Washington. The first report issued by the Bureau contained a reference to the proposed scheme which had been suggested to the Bureau by Mr. M. R. Tracy, of Satchie, O.

In the spring of 1883 one of the railroads connecting Columbus with Cleveland, the Cleveland, Mt. Vernon & Delaware R. R., consented to undertake the experiment, offering to bear the expenses necessary in equipping the cars with the necessary signals. The subject of the most suitable system of signals received careful consideration. It was important that those selected should be at once simple, easily interpreted and of such character as to be readily distinguished at a considerable distance. It was determined to confine the predictions, for the present at least, to forecasts of temperature and the state of the weather as to precipitation. Three forms were chosen called by the familiar names, sun, moon and star. These are shown in two colors, red and blue. The red signals refer to temperature and the blue to rainfall. The sun, a round disk nearly three feet in diameter, is understood to mean a probable rise in temperature if red or a general rain if blue. The moon, a crescent, means falling temperature if red, and clear or fair if blue. The star, five pointed, means stationary temperature if red and local rains if blue.

Experience has shown that these signals are admirably adapted to the service to which they have been put, being easily distinguished from each other and instantly interpreted after a little practice.

The Chief of the U. S. Signal Service, Gen. Hazen, has generously cooperated with the Bureau to secure the success of the experiment. Special telegrams have been sent, using the language of the signals, for the region of country traversed by the road. The trains bearing these signals on the baggage cars leave a point near the middle of the line about 5 o'clock a. m., thus bringing the forecast to the attention of residents along the line at an early hour. Verification observers have been appointed at nearly every station along the route, and thus far the predictions have been found correct in 85 cases in 100. The want of one or two additional signals has been felt, for occasional use in forecasting extraordinary changes, such as extreme cold, violent winds, etc. The matter is receiving consid-

eration but no selection of such signals has been made. The Bureau has furnished models of these signals to several persons interested in this work who are making efforts to have them placed on roads in other states, and it is intended to extend the system in Ohio during the present year.

The present status of the Bureau may be briefly stated as follows: Regular reports are received from about forty stations. Of these eight are rain-gauge stations, only five are U. S. Signal Service stations. Of the remainder sixteen are provided with barometers, in addition to the instruments listed above.

The appropriation made by the present General Assembly for the maintainance of the Bureau was two thousand dollars and one thousand additional for the extension of the service, particularly in the direction of railway weather service. From the beginning the Bureau has had much assistance from the Chief of the U. S. Signal Service, who undoubtedly recognizes that the existence of State Weather Services can but add to the efficiency and increase the usefulness of that over which he presides.

T. C. MENDENHALL.

HURON RIVER.

The following is a careful estimate of the water-shed above Geddes Dam, about three miles below Ann Arbor, with a measurement of the discharge of the river channel at the dam, and a comparison of the average annual rainfall on this water-shed, with the river channel discharge at this dam. The dam is new and well constructed and nearly water-tight.

The surface of the water-shed above the east line of Town Two South, Range Six East, taken from Farmer's Sectional Map of Michigan, is as follows:

Range 2 East, Town	1	North	18	Square Miles.
	1	South	24	" "
	2	"	18	" "
Range 3 East, Town	1	North	36	" "
	1	South	36	" "
	2	"	36	" "
	3	"	18	" "
Range 4 East, Town	2	North	3	" "
	1	"	36	" "
	1	South	36	" "
	2	"	36	" "
	3	"	24	" "
Range 5 East, Town	2	North	24	" "
	1	"	36	" "
	1	South	36	" "
	2	"	36	" "
	3	"	12	" "
Range 6 East, Town	3	North	6	" "
	2	"	36	" "
	1	"	36	" "
	1	South	36	" "
	2	"	36	" "
	3	"	18	" "
Range 7 East, Town	3	North	18	" "
	2	"	36	" "
	1	"	36	" "
	1	South	12	" "
Range 8 East, Town	3	North	36	" "
	2	"	24	" "
Range 9 East, Town	3	"	6	" "
	2	"	18	" "
Total			819	" "
Or say a total water-shed of			820	" "

Over this water-shed there is an annual rain-fall which averages 36 inches or one yard. There being 1760 yards in a mile the total annual rainfall on this water-shed in cubic yards is:

$$1760\times1760\times820=2,540,032,000 \text{ cubic yards.}$$

To carry this off by the river channel alone, without other loss, the discharge per second would have to average

$$\frac{1760\times1760\times820}{365\times24\times60\times60}=80.544 \text{ cubic yards.}$$

This is 80.544×27 or about 2175 cubic feet per second.

The Geddes Dam has an effective water-way of 200 feet. Besides this there is some leakage at the mill and some overflow at the waste gate of the dam. The head on this dam was taken on a day when the river was running banks-full and the mill shut down. It was found to be 1.7 feet. By Rankine's formula for the discharge over a dam with a flat crest (see Civil Engineering, pp 681, 682, 683 and 684), the discharge was, in cubic feet per second,

$$2,689\times200\times1.7^{\frac{3}{2}}=1192.3 \text{ cublic feet.}$$

Some allowance should be made for unavoidable leakages, and the discharge over the waste gates. This could not reach 10 per cent. of the discharge over the dam. It will therefore be fair as against the amount of required discharge to carry off the total rain fall to consider the total discharge on the day named as 1300 cubic feet per second. This is about 60 per cent. of 2175 cubic feet, or of the required discharge to carry off the total rainfall by the river channel alone. Or stated in another way, this appears to be true. If the Huron River should run banks-full constantly it would be able to carry away about 60 per cent. of the rain-fall on its tributary water-shed. But it does not run banks-full. It is considered that 0.5 of a foot on the Geddes Dam would be above the yearly average there; sufficiently so to cover other discharges at that place. By Rankine's formula this represents a discharge of

$$2,689\times200\times0.5^{\frac{3}{2}}=190.2 \text{ cubic feet.}$$

This is about 9 per cent. of 2175 cubic feet, or of the required discharge to carry of the rainfall by the river channel alone. If but one eleventh, or a tenth, or even an eighth, of the rainfall passes away by the river channel it becomes of interest to all needing water to know what becomes of the rest of it. Especially does this apply to those cities and villages needing a public water supply, that have no easily accessible surface source to draw from.

J. B. Davis, C. E.

Ann Arbor, Mich., 3-25-84.

BAROMETRIC WAVES OF VERY SHORT PERIOD.

The number of *Nature* for Dec. 20, 1883, contained an abstract of a paper presented by General R. Strachey to the Royal Society, wherein the author appeared to have demonstrated the reality of the novel and remarkable phenomenon of atmospheric waves travelling round the globe from the explosions of the Krakatoa eruption in the Straits of Sunda on Aug. 27, 1883, these waves spreading out radially from Krakatoa in a circular form round the globe, concentrating at the antipodes, then back again to Krakatoa, and so round and round for five days, the continuous barometric records showing two complete circuits of the globe in both directions at 8 out of the 13 stations furnishing the data, and at 5 of them a third circuit in one direction. The average time of completing one circuit was about 36 hours, but this varied considerably in the two different directions and also in the successive transits in the same direction.

This paper has created a wide-spread interest, and the novelty and importance of the phenomenon demand as complete an examination as possible, with the help of more data than were at General Strachey's command at the time of his preliminary investigation; especially as 12 out of the 13 stations used were European, and the great circles through them and Krakatoa take nearly the same direction, while that through Toronto, Canada, passing near the poles, gave a somewhat smaller velocity, perhaps due, as the author suggested, to the lower temperature of the polar regions.

A late number of *Nature* (Feb. 14, 1884, p. 355; also *Science*, Feb. 29, p. 244) brings the news that the Royal Society of London have deemed the Krakatoa eruption of sufficient importance to appoint a special committee to investigate all the phenomena connected therewith, the atmospheric waves among others.

As soon as Gen. Strachey's paper appeared, the writer applied for and, through the courtesy of the officers of the Signal Service (to all of whom his thanks are here tendered for their cordial co-operation) was kindly granted permission to examine the records of the self-recording barometers in use at the Washington office, and the results are of considerable interest.

In the first place the waves of Aug. 27 and 28, 1883, following the Krakatoa explosions, are by no means unique and not more remarkable than many other series scattered through the year. But they were all, to the writer, new and unexpected, and would seem to be a most remarkable feature of barometric fluctuations. Being waves of short period (varying from 5 minutes or less to more than 1 hour), they would rarely be detected by anything but self-recording barometers, and hence would not be generally known to meteorological observers in America, where so few of this class of instruments are in use. Loomis in his *Meteorology* does not refer to them, and a glance through the index volumes of the *American Journal of Science* discloses no mention of such waves. In England and on the continent, where self-recording instruments have been in common use for many years, it would seem that such fluctuations must be well known if they are a common phenomenon; but, in the European works on meteorology at the writer's command, no particular reference to them was found, although, as the examination was by no means exhaustive, such reference or description may very likely have been made.

Both on account of the remarkable nature of these barometric waves and the special interest attaching to those following the Krakatoa explosions, it is intended, so far as time outside of regular duties will allow, to investigate the probable or

possible causes of the phenomena as completely as the available date will permit, and the disturbances occurring during the last half of 1883 have been taken as the preliminary ground to work upon. A circular letter has been prepared calling for information, and this letter has been sent to all meteorological observatories where continuous barometric records are made or collected; and, as this letter describes the phenomena quite fully, it is here given both for the sake of that description and also to give, through the columns of THE AMERICAN METEOROLOGICAL JOURNAL, as wide a publicity as possible in this country to the call for information. The letter is as follows:

WASHINGTON, U. S. A., Feb. 23, 1884.

SIR—Being greatly interested in the remarkable phenomenon of atmospheric waves following the explosive eruption of Krakatoa in August last, (see paper in *Nature*, Dec. 20, 1883, p. 181), I hope to be able, through the courtesy of those who can furnish *tracings of continuous barometric curves*, to investigate the phenomena as completely as possible, and also to look for the causes of some apparently similar phenomena on other dates mentioned below.

Through the courtesy of the officers of the U. S. Signal Service I have been permitted to examine carefully the records of the continuous self-recording barometers in use at the central office at Washington, and have gone through the records of the last half of the year 1883. Below are given sketches of some of the most remarkable of the disturbances there recorded, of which, for the present purpose, the following explanation will suffice.

The vertical scale (as here reproduced) is magnified about three times, and the time-scale is $^{m}.013$ (about $\frac{1}{2}$ of an inch) per hour. The curves are not accurate tracings, but only free-hand sketches, and cannot be considered accurate over intervals of several hours, either as regards uniform time-scale or relative heights; but, *wherever waves occur*, they are drawn as accurately as possible, with respect to phase and period, and the interesting point to determine, if possible, is whether, with the exception of those following the Krakatoa explosions, they are all local phenomena, and, in any case, their causes.

With each section of curve is given the day and one or more hours of Greenwich Mean Time (astronomical, *i. e.* reckoned from Greenwich Mean Noon), but, pending an investigation which I am making of the rates of the chronograph barrels and the probable error of setting them, some of these times are probably 5^{m} or 10^{m} in error, or possibly 15^{m} or 20^{m} towards the end of the Washington Mean Day (5^{h}, G. M. T.).

The curves are copied from the record of a GIBBONS' self-recording barometer, in which a float in the short arm of a (J) barometer tube is suspended from the short arm of a lever whose long arm carries a thin platinum strip vibrating between two close platinum points, contact with either of which will, by the electric current thus closed, carry up or down by mechanical action a frame carrying these platinum points and graphite pencils recording on chronograph barrels. As long as the contact points are kept clean, the battery sufficiently potent, and the pencils sharp, this arrangement leaves nothing to be desired in the way of sensitiveness, promptness of action and sharpness of record.

Two other barometers recording in the same way are also in constant use, but they are not adjusted to be sensitive enough to show small waves, but the more remarkable waves are generally shown with sufficient certainty to furnish valuable data for correcting the time-scale of the GIBBONS when I shall have finished the investigation of the rates of all three and the probable error of setting any one of them.

Unfortunately the record of the GIBBONS is not always satisfactory (apparently through weakness of the battery), and once or twice, when the current was off for several hours, interesting records appear to have been lost. This is the case on Dec. 11, and notably on Dec. 18, when, from 17^h to $23^h.5$ (GIBBONS current not working), the other two barometers show, compared with their subsequent records, that there were series of waves probably as decided as those of Dec. 19, 0^h—4^h. Also the GIBBONS current was not working on Dec. 24 from 11^h till about 26^h, immediately following the very remarkable series from 5^h to 10^h on that day. On other occasions, like those of Nov. 10 and 16 and of Dec. 23, its apparently bad performance in some places makes other parts somewhat doubtful.

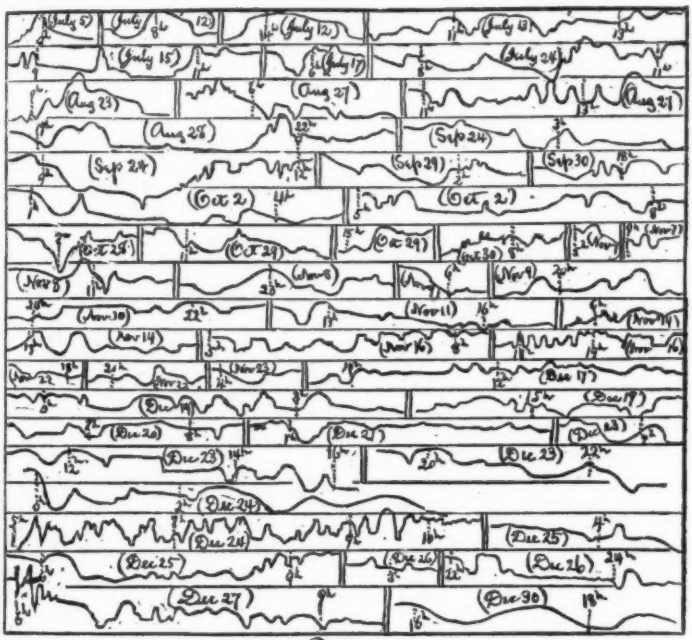

Fig. 1.

There is one mistake in the preceding sketches. On Dec. 23 the curve should be considerably lengthened out and the waves made flatter between 14^h and 16^h. Also I find that, in twice copying by the eye, I have sometimes unconsciously exaggerated the vertical scale, possibly in the case of some few prominent waves to the extent of $\frac{1}{4}$ the original amount, but in general they are fairly correct.

The curves of Oct. 30 and of Nov. 14 (about 6^h) are given principally as samples of the common record when *strong wind* is blowing, but this copy does not reproduce the sharpness of the original record.

Besides the waves sketched above, the following are prominent enough to deserve mention and thus make the 6 months' record fairly complete. The dates are all Greenwich Mean Time (astronomical). The following nomenclature is used in describing waves:

(+) = ⌒ ; (−) = ⌒ ; (±) = ∿ ; (∓) = ∿ ; (∅) =

period (approximate time from crest to crest); (*d*)—duration (to denote the length of a (+) or a (−) wave.)

1883.	D.	H.		M.
July	3.	11.5.	1 small (−) wave, (*d*)=	20
"	4.	15—18.	3 long (±) waves, (*p*)=	50
"	6.	13—14.	1 single (+) wave, (*d*)=	12
"	8.	8—9.	1 " (+) " " =	20
"	20.	22.8.	1 " (−) " " =	10
"	28.	15—16.	4 or 5 small waves, (*p*)=	12
Aug.	26.	21.1.	2 small sharp (∓) waves, (*p*)=	9
"	27.	2—3.	2 small (−) waves, (*p*)=	30
"	28.	2—4.	3 smooth (±) " " =	45
"	30.	5—9.	Long series of small irregular waves, 2 principal (+)	—
"	31.	19.0.	1 sudden fall (small)	—
"	31.	20.2.	1 " rise "	—
Sept.	2.	4—5.	1 " fall, followed by sharp (+) w., (*d*)=	12
"	2.	9.4.	1 " " (or wave)	—
"	2.	13—14.	1 smooth (+) wave, (*d*)=	20
"	3.	18—19.	2 small (−) waves, (*p*)=	30
"	10-22.		Several series of small insignificant waves, none very marked	—
"	23.	20—21.	1 single (+) wave, (*d*) =	15
"	24.	0.0.	1 " (−) " (*d*) =	20
Oct.	4.	13—20.	Series of small irregular waves, (battery working badly)	—
"	5.	19—24.	2 or 3 long smooth (±) waves. (*p*) =	140
"	11-23.		A few small insignificant waves	—
"	24.	17—23.	5 or 6 long waves (*p*) =	65?
"	27.	9—21.	Several series of irregular waves, (*p*) =	30?
"	28.	4.5.	1 sharp fall	—
"	28.	5.8.	1 small (−) wave (*d*) =	10
"	29.	2—3.	2 " (±) " (*p*) =	20
Nov.	7.	16—29.	Many very small irregular waves, a few prominent	—
"	9.	4.5.	1 or 2 irregular waves, (*p*)=	20
"	10.	0—8.	Several " " (*p*)=	50?
"	11.	2.5.	1 single (+) wave, (*d*) =	12
"	15.	6.2.	1 small (−) " (*d*) =	8
"	16.	8—10.	4 or 5 smooth (±) waves, (*p*)=	20
"	18.	14—17.	4 or 5 very irregular waves, (*p*)=	35?
"	21.	1—3.	3 or 4 " " " (*p*)=	40?
"	24.	2.4.	1 sharp rise (small)	—
"	25.	2.8.	1 " (−) wave, (*d*)=	10
"	25.	4.1.	1 " fall (small)	—
"	26.	10.0.	1 decided (±) wave, (*p*) =	35
"	26.	14.8.	1 large sharp irregular rise	—
"	30.	0—3.	Series of small irregular waves	—
Dec.	1.	9—12.	Series of irregular waves, (*p*)=	25
"	4.	10—19.	Long ser. " " mostly small	—
"	8.	8.3.	1 decided (±), (*p*)=	35
"	8.	9—11.	4 or 5 small waves (*p*), very irregular	—
"	11.	16.7.	1 (±) wave, (no battery afterwards), (*p*) =	30
"	12.	4—5.	3 irregular waves, (*p*)=	30?
"	12.	6—8.	Small irregular waves, (*p*)=	15
"	12.	10—16.	Occasional sharp (±) waves	—
"	14.	0.0.	1 (±) wave (*p*)=	25
"	14.	14—17.	2 series of small regular waves	—
"	15.	5—7.	2 or 3 irregular waves (wind superposed)	—
"	17.	21.8.	1 irregular (+) wave, (*d*)=	30
"	18.	1—4.	5 or 6 very irregular waves, (*p*)=	25?
"	19.	6—7.	2 or 3 small irregular waves	—

1883.	D.	H.		M.
Dec.	19.	20.7.	1 (—) wave (d)=.....	25
"	19.	23.5.	1 (+) " (d)=...	10
"	19.	24.0.	1 small sharp rise.....	—
"	20.	4.2.	1 " (+) wave, (d)=.....	15
"	20.	15—19.	Occasional very small sharp waves.....	—
"	21.	18.6.	1 small (—) wave, (d)=.....	12
"	22.	14—16.	3 or 4 irregular waves, (p)=.....	25?

It will be seen that the waves of Aug. 27 and 28, which have been attributed to the Krakatoa explosions, are not more remarkable than those of other dates, and a glance through the whole record of 1883 shows that they are about as frequent and remarkable during the first as the second half of the year.

An examination of the reports of *thunder-storms* from different parts of the United States, as printed in the *Monthly Weather Review* of the Signal Service, seems to render it probable that we may find in them and in the accompanying phenomena some of the causes of these barometric fluctuations. But more complete data as to time and place are needed than are there available.

In the hope of being able to collect sufficient data for investigating as fully as possible the causes of these phenomena, I venture to ask of those to whom this letter is addressed the favor of as much of the following data as can be furnished.

(1.) The latitude and longitude of the place of observation (to the nearest minute of arc, or as near as known) with a reference to the authority for the position, except in the case of well known observatories.

(2.) A copy (accurate with reference to place and time-scale) of the continuous barometric curve complete for the days, 1883 Aug. 26 to Sept. 4 inclusive.

(3.) The kind of self-registering barometer employed; the amount (if any) that the *vertical scale* is magnified; and the most probable correction (if known) to the *time-scale* all through the above interval; if this is not known, then some idea of its *probable error* at different times during the interval. (If no data exist on which to base an accurate estimate of this, then I would suggest that, in view of the importance of getting the most accurate data possible bearing upon this atmospheric wave question, it might be worth the trouble to make, as far as it can be done at the present time, an investigation of the most probable *rate*, possible *periodic error*, probable error of *setting*, etc., etc., of the time-registering apparatus of the barometer.)

(4.) An accurate copy of any other remarkable waves in the barometric record between the dates 1883 Aug. 16 and Sept. 15, (especially any that seem to correspond to that of Aug. 23 as sketched above), with the same data, as regards time-scale corrections, as noted above in (3.).

(5.) For the same interval (Aug. 16 to Sept. 15) as complete data as possible of all occurrences of *thunder-storms*, *lightning*, *hail-storms*, severe *wind and rain storms*, giving (as accurately as may be) the *time*, *duration*, *frequency of discharge of lightning*, *velocity and direction of wind*, if blowing, *amount of rain and time of fall*, *size and amount of hail*, if any; also any other displays of *atmospheric electricity* or any data bearing upon the *electric condition of the atmosphere*, and the *mean daily temperature* and *relative humidity* for each day of the interval. These data not only for the particular place of the observer, but, so far as he is able and kind enough to take the trouble, to collect all the accurate data possible of the same meteorological phenomena in as large a region as possible round about. In the case of European countries, data from the whole area, collected and systematically arranged by the Central Meteorological Observatory, would be especially valuable.

(6.) A careful examination of the continuous barometric records for the six months, 1883 July 1 to Dec. 31, to see if there are any series of waves which,

from coincidence of epoch with, or similarity of phase to, any of the remarkable series sketched above, can reasonably be attributed to atmospheric waves traveling round the earth; and, if any such are found, then accurate copies of them with the data as noted above in (2.) and (3.) and also the accompanying meteorological conditions as noted in (5.).

(7.) From observers in the middle and eastern part of the United States and in Canada, the same meteorological data as in (5.) for the whole interval from July 1 to Dec. 31, 1883, as complete as possible.

(8.) *Especially and particularly* in the case of *all the dates and times* referred to above, please be explicit as to what kind of time is referred to, whether *local, new standard* (in the U. S.), or *Greenwich;* and whether *astronomical* (counting from 0^h to 24^h from Mean Noon to Mean Noon), or *civil* time; and state from what source the time is obtained.

I address you, sir, with the hope that, if you can furnish data bearing upon any or all the above points, you will be so good as to send them to me, to the address given below, as soon as they can conveniently be prepared or collected; for which favor I shall be under great obligations, and trust that the labor may not be considered wasted. Especially would the copies of the curves for Aug. 26 to Sept. 4, 1883, with the most probable corrections to the time-scale, be most acceptable at as early a date as convenient.

Very respectfully, H. M. PAUL,

Address: { U. S. Naval Observatory, Washington, U. S. A.

P. S.—Since commencing the above (which has been delayed by interruptions), *Nature* (Feb. 14, p. 355) brings the news of the appointment by the Council of the Royal Society of a committee specially to investigate all the phenomena of the Krakatoa eruption. Since my proposed investigation touches only on the question of the barometric fluctuations following it (which from its importance is well worth several independent examinations), and in that particular is intended to cover 6 months of similar phenomena, it will be seen that they do not in any sense conflict, and I trust that no one will be deterred, through fear of a useless duplicate investigation, from sending me the data noted above.

WASHINGTON, 1884 March 10. H. M. P.

It is hoped that all readers of THE AMERICAN METEOROLOGICAL JOURNAL who can furnish any information bearing upon any of the points noted above will consider it addressed personally to themselves, and will kindly respond accordingly.

Now a few words as to the probability of being able to get at the true causes of these phenomena. It is very unfortunate that so few continuous self-recording barometers (or barographs as they are called in Europe) are in use on this side the Atlantic. The only ones known to the writer are at Toronto, at New York, (Central Park), and at Washington; and he would be glad to be informed of any others.[1]

These three stations are probably sufficient to give us some idea whether the above waves are to be studied as a local Washington phenomenon alone, or whether simultaneous disturbances occur over some such area as the eastern half of the United States; and, from whatever coincidence or want of coincidence as to place and time is shown at the three places, an idea may be gathered as to how

1 Since writing this, Dr. Draper, the director of the Central Park Observatory, has kindly informed me that one of his self-recording barometers is in use at the Providence Water Works, Providence, R. I.

far-reaching are the causes, whatever they may be. Of course no marked coincidence of phase is to be expected unless they are due to waves traveling round the globe from some single source like the Krakatoa explosions, and the comparison mentioned in the letter above will quickly determine that, if the various barographs are sufficiently sensitive and their records sharp enough to show all the small fluctuations of pressure. In this connection it is very probable that, on photographic records moving only about half an inch per hour, many of the details of waves like those of Dec. 24 would be lost, and this would certainly be the case with wind records like those shown above for October 30 and Nov. 14.

If the disturbances arise from thunder storms; then the individual effects are probably due to very local causes, and, if so, we should expect no correspondence of phase in the waves at Toronto, New York and Washington, though there might be simultaneous disturbances due to the similar wide-spread occurrence of such storms. The evidence in favor of the thunder-storm hypothesis is based simply on coincidence in time, so far as this can be determined by the records of the Signal Service as published in the *Monthly Weather Review*. For the four months, July—October these only give the dates upon which thunder-storms are reported as occurring in some part of certain very large areas, such as New England, Middle Atlantic States, Ohio Valley, etc. For November they are reported from separate states and for December from the separate towns or cities. These cannot be considered as complete records of all occurring thunder-storms, and, for the four months mentioned where the single areas are so large, they can give very little idea of the actual frequency of occurrence and areal distribution of the same. As they give no date as to the exact time, duration, severity, etc., of individual storms or definite parts of storm areas, they cannot be of use in any final investigation of the causes of the barometric fluctuations, but they are sufficient to furnish some indication as to the advisability of pushing the inquiry further. In examining them for this purpose the regions denoted by the Middle Atlantic States, Lower Lakes, Ohio Valley, Tennessee and South Atlantic States were alone considered, as being the area whence thunder-storms would most likely affect the Washington barometers. The results of this examination do not by any means conclusively show a connection between thunder-storms and these barometric waves, but they point to such storms and their accompanying phenomena as at least the most promising field for investigation. While there are many cases in July, August and September where thunder storms are reported from several of these circum-Washington areas with no accompanying barometric waves of any importance, and a few such cases in the last three months of the year, yet in general the maxima in the wideness of distribution of reported thunder-storms correspond quite closely with the maxima of sudden barometric fluctuation. Two curves plotted with ordinates about three days apart, these ordinates representing in one curve the number of thunder-storms reported from the whole circum-Washington area in the three days and in the other the amount of sudden barometric fluctuation in this interval, would, with a few exceptions, be quite similar, and in many places follow each other very closely. (Without much more complete and detailed information the thunder-storm curve could not be drawn much closer than with three-day ordinates.) The most marked exceptions to the similarity of these two curves would be that the thunder-storms, sometimes quite generally reported during the first half of August and the first half of September have no very decided corresponding waves; and, on the other hand, the somewhat remarkable waves of Nov. 14 and 16 have no thunder-storms reported from any part of the United States, from the 12th to the 17th, inclusive, and the waves of Dec. 17–21, inclusive, have none except from one place in Massachusetts on the 20th and from

one in Indiana on the 21st. Supposing the thunder-storm records to be anywhere near complete for these times, these last exceptions would bear rather strongly against the hypothesis of an immediate connection between the two phenomena; and the further fact that, taking the whole year 1883 together, there seems to be no preponderance of barometric waves during the summer months when thunder-storms are so much more frequent, is perhaps the strongest evidence of all against the hypothesis.

In this connection it may be noted that the whole year 1883, as compared with 1882, is much the more marked by these barometric waves of short period. The only such waves in 1882 that are at all comparable with many of those sketched above, are on Jan. 16–21 and on Feb. 21. From lack of time and because the records were not immediately accessible no examination has been made further back than 1882, and it is very possible that in these curves of 1883 we are dealing with a phenomenon not at all common. Those familiar with continuous barometric records can perhaps answer the question at once.

In favor, however, of the supposed connection between the barometric waves and thunder-storms, are very many striking coincidences, those of the series of waves of Dec. 23–27 and the wide-spread thunder-storms of those dates (the latter unusual for that time of year) being perhaps the most marked.

Another feature of these waves should not escape attention, and that is their diurnal periodicity which is quite decided. To show this the curves sketched in the above letter have been examined and the number of times each hour of the day is included in any of the curves was noted. Where one or two isolated waves occur between any two hours, both hours were taken, and when their mean falls very near some one hour, the preceding and following hours were included; and in general, with the long curves, the nearest hour preceding the beginning and following the end, and all between, were used. Then the waves enumerated in the table following the sketches were likewise treated, and $\frac{1}{4}$ the resulting numbers (since these waves were generally very small compared with the preceding) was added to the first numbers. The result is shown in Fig. 2 below, where the horizontal scale denotes the hours of the day and the vertical scale the sum of the above numbers, marked by a dot for each hour.

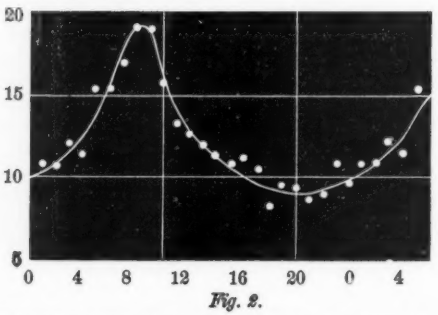

Fig. 2.

The smooth curve drawn through the dots shows a very decided maximum, (this would be much more decided from the principal waves alone) at about 8^h or 9^h and a minimum about 12 hours later; all tending to indicate that in these curves for the most part at least, we are dealing with a phenomenon due to local causes having a marked diurnal period. The curve approximately agrees with the diurnal temperature curve, and so far as the maximum disturbance falling at 8^h or 9^h

(3^h or 4^h of the local M. T.) is concerned, it may be considered as confirming in some degree the reality of its connection with thunder-storms as a cause.

Any possible connection with other meteorological phenomena, such as hail-storms, violent wind or rain storms, areas of high or low barometer, etc., it is proposed to investigate as far as there seems good reason for doing, and the writer would call the particular attention of the readers of THE AMERICAN METEOROLOGICAL JOURNAL to items (5.) and (7.) in the above letter; and to the data mentioned in (5.) he would now add the *maximum* and *minimum* as well as the *mean* daily temperatures. Whether it will be possible to collect sufficient data regarding thunder-storms to settle the question of their connection with barometric fluctuation is perhaps doubtful, but the cöoperation of all those who have such records for places in the eastern half of the United States and in Canada, or who know of any such records being kept, is earnestly desired in order that the data may be as complete as possible.

Until a connection between thunder-storms and these sudden changes of pressure can be definitely shown, perhaps it is idle to speculate as to what may be the exact connecting link; but the following questions would seem to be pertinent:

1st. Could large thunder-clouds, charged with electricity of very high potential, be, by their mutual attraction or repulsion, moved about horizontally, and, through the viscous resistance of the containing medium, drag large masses of air with them in such amount as alternately to increase or diminish the actual weight of the atmosphere over any place in a manner indicated by such curves as those of Dec. 24 and 27 shown above? (The most extreme sudden fluctuations in any of the curves do not correspond to more than about 2^{mm} or about $\frac{1}{350}$ of the entire weight of the atmosphere.) This explanation would be in accordance with known electrical and mechanical laws. Or,

2nd. Are we dealing here with phenomena of atmospheric electricity of which thunder-storms and sudden changes of pressure are only two distinct and independent manifestations, having a common cause but not necessarily concomitant? This would best accord with facts as at present known, especially with the important one that, as far at least as 1882 and 1883 are concerned, the barometric disturbances are not more marked in summer than in winter, but rather the reverse if there is any preponderance; and also with one or two recent facts noted since Jan. 1.

On 1884 Feb. 17 there was considerable thunder and lightning in Washington from about 18^h to 20^h, Washington M. T. (astronomical), but the Signal Service barographs show considerable sudden disturbance at intervals through nearly the whole day.

On Feb. 22d the station record says that a thunder-storm passed over at $13^h\ 45^m$, and the most sensitive barograph shows a few very slight irregular waves at about that time, and nothing else during the 24 hours.

On March 8th there was heavy thunder and lightning at intervals from $21^h\ 16^m$ to $22^h\ 39^m$, and the barographs all show very violent disturbances at intervals all through the 24 hours, (one wave somewhat similar to but with even greater range and steepness than that shown above at about $6^h\ 15^m$ on Dec. 27th), but there is no particular maximum at the time of the local thunder and lightning.

On March 25th destructive cyclones are reported from various places in Georgia, South Carolina, North Carolina, Tennessee, Kentucky, and Virginia, in some cases accompanied by severe hail as large as hens' eggs. At Washington there was thunder and lightning with heavy rain from 12^h to $12^h\ 35^m$, but not much wind. The barographs show considerable irregular fluctuations all through the day, though hardly so much as on March 8th, but the principal feature is a quite

sudden and very irregular fall amounting to about 3^{mm} of mercury at about the time of the local thunder-storm.

These two questions lead to what would seem to be the most important of all to investigate, viz:

3d. Does the *pressure* of a given mass of gas, or of a mixture of gases like the atmosphere, depend only upon its *volume* and *temperature* as expresed by the formula,

$$P = \tau \frac{M}{V} \kappa$$

in which τ is a coefficient varying with the temperature, and κ a coefficient nearly equal to unity but different for each gas or mixture of gases? Or, may the pressure also vary in some slight degree with the *electric potential* either of the surrounding media or of impurities (like condensed vapor, smoke and dust particles, etc.) contained in the gas and capable of carrying a charge of electricity? And, if this is the case, do these variations of pressure, developed at rounding surfaces or locally in some parts of the gas, extend uniformly throughout its mass, or do they vary from one equipotential surface to another?

These questions, so far as known to the writer, have never been raised, and he has some diffidence in suggesting them to physicists; but they would seem to be worthy of consideration, and some of them perhaps capable of test by laboratory experiment up to potentials as high as can be generated with influence-machines. Even if this should be without result we are probably very far from approaching the potentials common in thunder-clouds. If any such connection between electric potential and gaseous pressure could be shown, its possible bearing upon the theories of electric and magnetic molecular action and the kinetic theory of gaseous molecular motion would seem to render its careful investigation highly desirable.

Bearing upon this question the Signal Service could probably furnish important and interesting data by establishing on some such high point as the Pike's Peak Station, where electric-storms are frequent, electrometers (continuously self-registering if possible), measuring the potential of the atmosphere, and also sensitive barographs. And, to make the data still more complete, two or three similarly equipped stations round the base of the mountain would be highly desirable. At the same time a record of the thunder and lightning, as continuous as possible, should be kept at each of these stations, this record to include as nearly as may be the exact time of each flash of lightning, its azimuth, the interval between the flash and the first thunder, and the duration and character of the peals of thunder. The times should be recorded upon a chonograph and the azimuths would be determined with sufficient exactness by the same observer standing near a large circular board (fixed at a convenient height on a post), upon which azimuths were correctly laid down from 0° to 360°, so as to be read off at a glance, with means for illuminating it at night. For each observer one or two recorders would be needed to put down the observed azimuths, the order, etc., of the chronograph marks, notes, etc. Perhaps several such equipments and parties for each station would be desirable in order to cover the whole ground when thunder-storms were widely distributed and lightning frequent. Probably two or three months of such systematic observation by summer parties would give us more information about the laws of thunder-storms and their connection with atmospheric electricity and the other accompanying meteorological conditions than all that has been done heretofore, and the continuous electrographic and barographic records could be kept up indefinitely by the regular station observers.

Referring again to the atmospheric waves following the Krakatoa explosions, it is evident that the discussion of the question cannot profitably be carried much farther than already done by General Strachey until much more complete data are available from all possible parts of the earth. In the Washington records there are waves on Aug. 30 and 31 which will perhaps prove, if they can be certainly identified, to be third and fourth pairs of transits of the wave in opposite directions, and it is barely possible that in the small waves of Sept. 2 and 3 there may be picked out succeeding transits; but this is very unlikely, for the reason that they are probably only a few of many waves due to other causes, and especially because Washington is only about 33° from the antipodes of Krakatoa, and, if the waves have different velocities on different great circles and also different in opposite directions, the phenomena near this place would grow more and more complicated at successive transits, while they rapidly diminish in distinctness of record. A discussion of this question must be reserved for a future communication when there shall have been time to examine it more fully with the aid of additional data.

H. M. PAUL.

Washington, 1884 March 27.

BAROMETRIC GRADIENT AND WIND VELOCITY.

The barometric gradient may be defined as the amount of rise in air-pressure experienced in a distance of 1° on the earth's surface, that is about 69 miles. We may measure the actual wind velocity associated with a certain gradient and thus obtain an average value for that gradient. Various results have been obtained which differ largely from each other and are quoted from time to time. The following table exhibits values as taken from several authorities:

BAROMETRIC GRADIENT AND WIND VELOCITY.

Velocity.		Gradient millimetres in 1° (69 miles.)				
		Prof. Loomis.				
Miles Per Hour.	Metres Per Second.	8th Paper.	19th Paper.		Peslin.	At Kew.
			Sea.	Land.		
5	2.2	1.37			.70	.20
10	4.5	1.50			1.25	1.02
15	6.7	1.68	1.88	1.98	1.75	1.73
20	8.9	1.77	2.35	2.45	2.70	2.34
25	11.2	1.86	2.78	2.95	3.08	2.97
30	13.4	2.16	3.02		3 44	
40	17.9	3.44			4.48	
50	22.4	3.89			5.06	

It will be seen that these values differ largely among themselves. The differences are due to varying methods of determining the values. Prof. Loomis in his 19th paper states, it is necessary to study the problem under relatively high and low pressure, different temperatures, differen
tions to the isobars and at different distances from the centre. It is suggested that in addition to the above points attention should be paid to irregularities of the earth's surface, effects of local causes upon wind direction and velocity, the velocity of movement of "high" or "low," the quadrant about either "high" or "low," the effect of cloud and sunshine, the effect of diurnal range in velocity, etc.

It is believed that the latter point is of much importance, and that the results derived from observations in the early morning would be far different from those in the afternoon. There is an interesting point in this connection which seems to have escaped attention: it is this, frequently, we have a high wind velocity, upon the approach of an high area from the west, during the day hours, but soon after the sun has set the wind dies down to nearly a calm only to rise again after the sun has risen the next morning; during this time the gradient has remained very nearly constant, as whatever affects the isobars affects all alike in any region. May there not be an influence affecting the wind's velocity entirely distinct from the gradient or that producing it? In such case it is easy to see that the connection would not be an invariable one, but the gradient would be in a measure independent. The fact that the wind is seldom steady, but blows in regular gusts, would also point to an independence of the two. H. A. HAZEN.

Washington, D. C.

ON THE RELATION BETWEEN NORTHERS AND MAGNETIC DISTURBANCES AT HAVANA.*

In the publications of the Havana observatory for 1872–'73 and '74 the director, Benito Viñes, has compared the magnetic and meteorological records (the latter obtained from Secchi's Meteorograph), and states that the observations show a connection between magnetic disturbances and "northers."

The importance of the subject both to meteorology and magnetism seemed sufficient to warrant a careful examination of the Havana observations to discover, if possible, the nature and amount of evidence sustaining the hypothesis.

The liability of suspended magnets to mechanical disturbances during sudden and large changes in temperature and humidity, renders special investigation and experiment necessary in order to make sure that the perturbations are due to true magnetic changes, and are not the result of instrumental errors. But no such investigations seem to have been made by Viñes and the observations are consequently subject to this uncertainty.

From a careful inspection of the Havana observations, together with data obtained from the publications of the U. S. Signal Office, a tabulation has been made of northers, auroras and magnetic disturbances.

A study of the coincidences between these phenomena showed:

1st. Many (nearly one-third) of the northers occurred with no magnetic disturbance accompanying; the magnetic curves presenting only the normal daily oscillations.

2d. Of northers coinciding with magnetic disturbances, a portion occurred during the manifestation of electrical and magnetic phenomena, such as auroras and solar eruptions, at which times the magnetic needle is invariably disturbed.

3d. The number of magnetic disturbances was at times so large as to make the mathematical probability of accidental coincidences with northers a maximum. This was determined by means of a formula based on the theory of chances.

The last two of these facts show that conclusive or even satisfactory evidence of the effect of northers can not be obtained from observations taken during a period of maximum auroral and magnetic activity. For, at such times, the effect of electric currents in the atmosphere, prevailing during any specified weather

* Abstract of a paper read before the Philosophical Society of Washington, March 15, 1884. From the author.

conditions, can not be separated from the more powerful causes of magnetic disturbance proceeding in some way from the sun, but which, as far as we know, affect the meteorological elements—pressure, temperature, precipitation, etc.,—in a very slight degree, discoverable only in the mean of many year's observations.

If, therefore, the increased magnetic activity during a period of maximum sun-spots can not be attributed to differences in the meteorologic conditions, but is caused by magnetic action independently of the weather, then, in order to ascertain whether the magnetic needle is affected by any given atmospheric changes, we should study only periods of minimum sun-spots when the needle is least affected by other sources of disturbance.

For these reasons the observations presented by Viñes seem insufficient to render probable the connection between northers and magnetic disturbances which he advances.

GEO. E. CURTIS.

THE TWILIGHT PHENOMENA.*

The study of the unusual phenomena which marked the last months of the year 1883, and which have been reported from all parts of the globe, is still in progress, and seems far from a termination. An English magazine distinguished for the extent and variety of its information, *Nature*, has brought us valuable facts in each number since last October. We find other no less interesting information in the *Comptes rendus* of the Academy of Science, in the review *l'Astronomie* and in other scientific publications. We can from the present time try to arrange these materials and select from them the most striking facts.

That which struck the observers from the first, even the least attentive ones, was the extraordinary duration of the twilights and the intensity of the coloring of the sky. In Europe, this red light which seemed to prolong the day was particularly noted during the months of November and December.

There was a hesitation at first to believe it anything but the ordinary sunset or twilight, observed under atmospheric circumstances which were particularly favorable.

Mr. Piazzi Smyth (*Nature*, Dec. 13), remembers that thirty years ago he often watched the sunsets for the purpose of reproducing the transitory coloring, and that he more than once observed a play of light quite as remarkable, when the air was very pure and dry. But as information multiplies, it has become necessary to search for some other explanation of these phenomena.

Mr. Gerard Hopkins (Stonyhurst) has devoted himself to bringing out the peculiarities which distinguish these twilights from the phenomena generally understood by the words sunrise and sunset. (*Nature*, Jan. 3). In the first place the red hues manifest themselves long after the sun's disk has disappeared below the horizon (afterglows), or long before it appears (foreglows). According to the very precise observations of Mr. F. A. R. Russell (*Nature*, Dec. 13.) there were most often two distinct maxima, separated by regular intervals; a primary maximum, fifty-six minutes before the rising or after the setting of the sun, and a secondary maximum fifty-one minutes before or after the primary maximum, of which it seemed to be a distant reflection. In the succession of the different phases, and in the distribution of the colors, there was a characteristic regularity which is not to be observed in the ordinary sunrise and sunset. The light rose at times very high in the heavens, even beyond the zenith, instead of remaining con-

*Translated from the *Bulletin astronomique* for Jan.

fined to the horizon. It was of an intense red, but deprived of that metallic-like brilliancy of color which invests the clouds of which the setting sun seems to gild the edges. It had something of the tranquil light which reigns in a *salon* discreetly illuminated. At the beginning of the phenomenon the colors succeeded each other generally in the following order from the horizon: below, orange, then green, a crimson-red and a pale lilac which soon disappeared, at the same time that the orange was replaced by the green, which in turn gave place to red, so that finally there remained only a scale of red tones ranging from scarlet to crimson. But these colors were never pure. The green seemed to be half way between apple-green and olive-green. The red verged upon brown. These glows seemed neither to emanate from a bank of clouds nor from a transparent medium.

This description which, we have abridged, has seemed to us to summarize clearly the principal traits of these periodic illuminations of the sky, reported by so large a number of observers. It is clear that atmospheric circumstances which differ according to place, and vary from one day to another, must have modified everywhere the appearance of the phenomenon, and it would be tedious to mention all the variations which exist in the different descriptions published in the last few months. The account which comes nearest to the preceding one is that which Mr. Edward Divers has sent from Japan. (*Nature*, Jan. 24.)

Some observers, among others Helmholtz (*Nature*, Dec. 6), have given the opinion that the greenish hue of certain regions of the sky was due only to contrast, provoked by the presence of the red; but others affirm that they have been able to convince themselves that this coloring persisted when the eye was protected from the influence of the red, (Mr. Russell, *Nature*, Dec. 13).

Mr. Sydney Hodges says that he has seen the moon green upon a background of gray-blue, when there was not a trace of red in the sky. In many accounts there has also been a question of a rose colored arch which was seen opposite the sun in the east a short time after sunset, and in the west just before sunrise, (Mr. Backhouse, Mr. Edm. Clark, and Mr. Divers, *Nature*, Jan. 10 and 24).

By daylight have been noted other curious phenomena. In India, in the beginning of September, a large number of witnesses saw the sun, now blue and now green. Professor Michie Smith, at Madras, has shown at the same time a strong absorption in the red and at the blue extremity of the spectrum, and he concluded from his spectroscopic observations that the air was strongly charged with humidity.—(*Nature*, Oct. 11th and 25th, and Nov. 8th and 15th.) In Italy according to M. Tacchini, (*Nuova Antologia*, Feb. 1st,) the optical phenomena were also accompanied by a strong humidity, discovered by the hygrometer and the spectroscope. On the contrary, Mr. Piazzi Smyth has found the air particularly dry; M. Alluard reported this as being true on the summit of Puy de Dôme.—(*Comptes rendus*, Jan. 21.) These contradictions would seem to indicate that the cause of the phenomena in question should not be sought for in the state of the lower strata of the atmosphere at the place of observation.

At the same time that the sun appeared colored, its light diminished; this is stated in the letters from Ceylon and from Cape-coast Castle and elsewhere (*Nature*, Nov. 1st, Dec. 6th.). Some observers saw a diffuse halo of a bluish-white bordered with red about the sun, (M. José J. Landerer, *Comptes rendus*, Dec. 31st; M. E. Marchand, *Comptes rendus*, Dec. 24th; Mr. E. Divers, *Nature*, Jan. 24th.) At the summit of Ben Nevis, Mr. Omond saw the coloration of the horizon continue the whole day,—(*Nature*, Jan. 17).

These are the principal facts collected from the very numerous accounts which we have seen. It remains now to seek an explanation. That which seems indisputable is that we are in the presence of phenomena of reflection, produced

by some material finely pulverized, extremely transparent, which exists in the atmosphere at a level more or less elevated.[1]

The whole question is to know what is the nature and what the origin of the matter which floats above us like an invisible vail changing the light of the sun, prolonging the length of the day and coloring the twilights by successive reflections of distant sunrises and sunsets. Have we to do with meteoric dust, with ashes from a volcano, with vesicles of water or with crystals of ice?

The greater number of witnesses whose depositions have been recorded by the scientific journals, mention the close relation which seems to exist between these optical phenomena and the terrible eruption of which the Strait of Sunda was the theatre. The volcanoes of Java had been singularly active since May. It was the 26th and 27th of August that the catastrophe took place which cost the lives of 50,000 persons, We know that the island of Krakatoa disappeared with the volcano which it bore; that new islands surged up from the bosom of the waves; that the sea was covered with floating fields of pumice stone; boats which passed within a radius of 500 miles received the rain of ashes during the days following the eruption. The great wave caused by the breaking up of Krakatoa made the circuit of the globe at the rate of about 360 miles (670^{km}) an hour, and was registered by our maregraphs.[2] According to the researches of General Strachey, founded upon the comparison of barometric observations, (*Nature*, Dec. 20), an atmospheric wave left Krakatoa Aug. 27, at 9^{h} 30^{m} in the morning, spread in two opposite directions from east to west and from west to east with a velocity of about (1100^{km}) 600 miles an hour; it made the circuit of the globe several times taking each time about thirty-six hours to accomplish it. This is scarcely inferior to the rate with which sound travels.[3]

The facts just cited prove the violence of the commotion produced by the cataclysm of Java. In admitting that the destruction of Krakatoa was due to an explosion occasioned by infiltrations of sea-water, it may be conceived that prodigious masses of vapor and ashes must have been thrown to a great height and must have penetrated into the region of the upper currents, which carried them immense distances. The observation of the cirri has given more than once for these currents velocities between 150^{km} and 250^{km} per hour, which is sufficient to pass in one day the distance from Java to Ceylon or even to Maurice Island. Thus may be explained the rapid transport of the impurities which changed the aspect of the sun and the presence of which was soon reported from all parts of the globe. Aug. 27th it appeared at Reunion, the 1st or 2d of Sept. in the latitudes of New Ireland and in Central America; Sept. 5th at Honolulu (Sandwich Islands); the 9th at Ceylon and in a great portion of India.[4] In Europe the first observations date no farther back than the beginning of November. The phenomena were still seen in the month of January.

The partisans of the opinion which attributes these phenomena to the diffusion of ashes thrown by the volcanoes of Java can invoke, in addition to the concordance of dates, a series of proofs which are not without importance. In the first place must be cited the microscopical analyses of the sediment left by rain

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1 The absence of all magnetic perturbation suffices to do away with the hypothesis that it is an Aurora borealis.

2 M. Bouquet de la Grye,(*Comptes rendus*) Nov.26. The velocity of 2000 *km* an hour found by M. Erington de la Croix (*Comptes rendus* Dec. 31), rests upon an error in calculation; the local times were compared without taking into account the differences in longitude,

3 See also the notes by M. Renou, by M. Wolf and by M. Marie-Davy (*Comptes rendus*, Jan. 21st and 28th.

4 According to M. Pelagand, (*Comptes rendus*, Jan. 28th), these twilights have been observed the length of a zone, of which the axis begins at the Strait of Sunda and ends to the south of Madagascar.

or melted snow. An English geologist, Mr. J. Macpherson, declares that having examined newly fallen snow, at Madrid, Dec. 7, he found among other dusts, crystals of hypersthene, analagous to those which M. Daubrée found in the ashes of Java, (*Nature* Dec. 20th and Jan. 3d). MM. Beyerinck and Van Dam, who were charged to analyze the volcanic ashes sent from Java to the laboratory of Agricultural Chemistry at Wageningen, (Holland), had the opportunity to show certain analogies between the ashes in question and the gray sediment which a heavy rain had deposited on the windows exposed to the north-west, on the 13th of December.

This observation was renewed Jan. 11th, (*Nature*, Dec. 20th and Jan. 31st.) In England Messrs. Burton and Edm. Clark collected sediment left by the rain of Dec. 12th, (*Nature*, Jan. 3d.). From Geneva, M. E. Yung writes to the Academy of Science, (*Comptes rendus*. Dec. 17th), that for three weeks he found in the products of rain-fall, and in water obtained from a fall of snow, the presence of globules of iron in exceptionally great numbers. Dec. 18th, in Westphalia, there was a fall of snow accompanied by black dust. At Glen-Grey, in the vicinity of Queenstown, (Cape Colony), there fell, Nov. 28th, a great quantity of globules formed of a whitish material which was reduced to powder at touch, (*Nature*, Jan. 10th.) These, then, not to look too closely, are the tangible proofs of the presence of volcanic ashes in our atmosphere. But these proofs lose a little of their value when we remember the numerous cases of dust rains, collected in the interesting little book of M. Gaston Tissandier on the *Poussières de l'air*. M. Nordenskiold has, in his turn, made the presence of charred particles, containing iron, silica, phosphorus and cobalt in the sediment of the snow recently collected in Sweden (*Comptes rendus*, Jan. 21st), count against the theory of the volcanic origin of the dust.

Again, there are facts of a different order which seem to corroborate the explanation generally adopted of the unusual phenomena which occupy us. They are evidences, more or less old, establishing the coincidence of phenomena of the same character with volcanic eruptions.

In the first place, the dry fog of 1783 followed closely the eruption of Skaptar-Jokul, (there was the same year a great eruption in Japan; exactly as last year the catastrophe at Java was followed in October by the apparition of a new volcano in the Aleutian Islands.) But it is particularly the dry fog of 1831 which offers striking analogies to the phenomena of 1883. According to Arago (*Annuaire du bureau des longitudes pour 1832*), the fog was reported for the first time Aug. 3d, on the coast of Africa, the 9th at Odessa, the 10th at Paris and in the south of France, the 15th at New York, and toward the last of the same month at Canton, China. Everywhere the sun's disk appeared azure-blue, greenish, or emerald-green. The nights were of singular clearness. All the journals reported the exceptional length of the twilights and the red color of the sky. Kastner collected these facts in volumes IV. and V. of his *Archives de Météorologie*. Extracts may be found in the *Traite de Meteorologie* by Kaemtz (Vol. III.) Now it was in July that the sub-marine eruption took place, which caused the appearance of the island of Julia in the Mediterranean.

These observations may be compared with the statement of Mr. Edward Whymper, who, July 3, 1880, found himself on the western slope of Chimborazo, about 100^{km} south of Cotopaxi, where he saw issue from Cotopaxi a column of smoke which soon attained an altitude of about 12,000 metres. Carried first by an east wind, and then turned toward the south by another current, the ashes from the volcano arrived over Chimborazo, veiling the sun, which seen through them appeared to be emerald-green. The sky presented large green spots of which

the hue changed suddenly to red, (*Nature*, Dec. 27th.) Colonel Stuart Wortley remembered in his turn the splendid coloring in the sunsets which he saw at Naples during the eruptions of 1862, (*Nature*, Dec. 20th.)

That which it is necessary to bear in mind is, that volcanic ashes dispersed by the wind can give rise to optical effects resembling those which have attracted all eyes during several months. This does not exclude the subsidiary intervention of other causes, among which it will be permitted to mention cosmic dust with which the terrestrial atmosphere is incessantly sprinkled. Mr. Piazzi Smyth says that according to the most moderate estimates, our atmosphere receives about 100,000^{kg} of meteoric dust per day, which is disseminated in the form of impalpable powder and slowly brought to the earth. During his sojourn upon the peak of Teneriffe he observed moreover the presence of veritable strata of dust, scarcely visible, which seemed to exist in a permanent state at a very high level. Mr. Langley had occasion to make an analogous observation during the ascension of Mt. Whitney, in 1881. Having reached an altitude of 4,500^{m} he saw below him, extending as far as the eye could reach, an ocean of dust which seemed reddish by reflection, and which he had not seen from below. A distinguished geologist, Mr. Clarence King, has given as his opinion that this dust must come from the deserts of Central Asia, (*Nature*, Jan. 31st.) The Baron von Richthofen, in his journey in China, mentioned also the clouds of yellowish dust with which the air is always charged in those regions, and which give to the sun a pale-blue color. Mr. Langley thinks that a continuous envelope of dust entirely surrounds the earth. Perhaps electricity plays a role in the suspension of this dust in the very highly rarified air. We must not forget the important role which devolves, in the phenomena of meteorological optics, upon those fine needles of ice which give rise to the cirrus.

As M. Alluard has remarked, (*Comptes rendus*, Jan 21st,) to explain certain effects of light, it suffices only to admit a stratification of atmospheric layers, produced by an irregular diminution of temperature. M. Tacchini, in the article already cited sustains the opinion that the long twilights are closely connected with the hygrometric state of the atmosphere; to those who quote the eruption of Java to explain the unusual color of the sky, he opposes the numerous eruptions which seem to produce nothing of the kind. It will be time to choose between all these explanations when we know more completely the sum of the observations, to which the singular phenomena of 1883 have given rise. That which seems to be proven is that we have to do with phenomena of reflection due to the presence of finely pulverized matter, the nature of which is still to be determined. The light thus reflected is, without doubt, only the light of the setting sun colored by transmission across the lower strata, charged with vapor.

R. RADAU.

A NEW ACTINOMETER.

(Note by M. G. A. Hirn.*)

This instrument rests upon the principle of the large surface condenser of steam-engines; a saturated vapor, contained in a closed receptacle, assumes the tension which corresponds to the minimum temperature of the sides of the enclosure. The following is the way in which the principle is utilized in a particular case:

Let us imagine an alembic of which the cucurbit is exposed to the sun, and of which, on the contrary, the worm and the receptacle of the liquid to be distilled

*Translated from *Comptes rendus* No. 6.

is placed in the shade, but still out of doors. Let us place in the cucurbit a volatile liquid: water, alcohol, sulphuric ether, bisulphide of carbon. We will soon see which must be chosen. Make the space in the apparatus such that it will contain only the vapor which the liquid engenders. What will happen? Suppose, in the first place, that the sky is completely cloudy, so that the whole apparatus shall be out of doors, at the same temperature; the liquid will remain like that in the cucurbit; no distillation, no condensation in the cooler will be manifested. From the time the clouds clear away, from the time that the solar rays strike the cucurbit, the heat absorbed by the walls, instead of warming the liquid, instead of elevating its temperature, will make it boil at the tension which accords with the minimum temperature of the apparatus,—to that of the refrigerant, and that of the reservoir placed in the shade. If the surface of these last is sufficient so that the heat, which is constantly supplied, disperses rapidly in the ambient air, the temperature of the whole apparatus promptly becomes stationary and will be but little greater than that which is marked by a thermometer placed in the shade, at the side of the cooler.

The quantity of solar heat received in the unit of time by the walls of the cucurbit will be almost exactly proportional to the quantity of liquid also condensed in the unit of time. By the aid of the equations of Regnault, concerning the total heat of evaporation of the liquids with constant pressure, we can calculate rigorously the solar heat absorbed by a known surface, without having, so to speak, to turn to any correction concerning accessory losses, the mass of the liquid, of the metal, etc.

Such is the design, in some sort theoretical, of the integating actinometer. Let us see how it may receive a practical experimental form, such that its indications will be reliable, and also easy to read.

1. The cucurbit consists of a thin tube of copper six-tenths of a meter in length and one-tenth in diameter. This tube, closed below and terminating in a cone above, is placed parallel with the axis of the earth, from which it results that, during the course of a day, the solar rays strike the periphery at nearly the same angle. From four-tenths of a meter above the lower part, the tube is protected against the sun's rays, so that the level of the liquid always surpasses considerably the part which receives the solar heat; it is besides held so as to be free in every sense; it is painted with lampblack so that the heat lost by reflaction shall be reduced to a minimum. At the apex of the cone is soldered a tin tube, of small diameter, which at first makes a steep slope upward, then descends regularly to terminate in the worm. This tube has as much as possible to its entire surface exposed to solar radiation, so that there shall be no condensation in operation there.

II. The worm, or condenser, is placed in the shade in a part of the observatory where a thermometer will indicate with certainty the effective temperature of the air. It consists of a copper tube of $\frac{5}{100}$ meters in diameter and 6^m5 in length, regularly rolled on a screw $\frac{1}{10}$ of a meters in diameter, with a rather steep slope.

It will be seen that the cooling surface is 1.02209 meters, and consequently 25.5 times that of the cucurbit (0.04 sq. meters) exposed to the sun.

III. The lower extremity of the worm turned vertically down terminates in a cone to which is puttied a glass tube divided into equal volumes to a height of $0^m.8$. Below this glass tube is puttied a cone to which is soldered a second tin tube which comes below the cucurbit, and which is provided with a stop cock. The lower part of the crystal tube is higher than the upper part of the cucurbit, so that when the valve is opened the condensed liquid returns to its starting point.

IV. The choice of the liquid employed is not unimportant. Water will not answer for three reasons: 1st, in winter it would prevent the instrument from

working on account of freezing; 2d, it would not always moisten the walls of the worm with whatever care they were cleansed, and the flow into the receptacle would be intermittent; 3d, finally, its heat of evaporation being very great, but little of it would be distilled in a unit of time, even by very intense solar radiations. On the other hand sulphuric ether is changed, as we know, after a time; and the experiments of Regnault show that alcohol follows a very irregular law of evaporation. Among the liquids which have been well studied the only two which have seemed to me to be free from these various inconveniences are bisulphuide and bichloride of carbon. I stopped at the first because of its great volatility, although the fastening of the glass to the copper presents real difficulties with a liquid which dissolves nearly all the resins.

V. According to Regnault, the law of evaporation of sulphur is

$$q=90+0,14601t-0,0004\,123t^2.$$

At 35°, then it requires 94,6—90=4ᶜ6 more to evaporate 1^{kg} of this body than at zero. Although small in itself, this difference cannot be neglected. It is necessary then to know, at the very least, the mean temperature at which the distillation in the actinometer takes place. This temperature may be determined with great precision by the aid of the mercurial manometer fixed to any part of the instrument. This manometer, in effect, in showing the tension of the vapor, also tells us the temperature.

VI. Notwithstanding the enormous relative surface of the worm or condenser, it is impossible that the temperature should not rise a little above that of the ambient air, when the atmosphere is pure. A thermometer placed in the shade beside the cooler is useful in making possible the slight corrections which this rise in temperature necessitates.

VII. I have remarked that the axis of the cylindrical retort is placed parallel to that of the earth, so that the angle at which the solar rays strike the surface may be nearly constant during the course of a day. If we designate by O the mean declination of the sun for each day, by L the length of the part exposed to the sun, and by D the diameter of the cylinder, we have for the value of the lighted surface,

$$S=D\ L\ cos\ O,$$

and, as the metal is painted a dull black, we may without great error, admit that the calculated surface is equivalent to a plane surface of the same value; in other words, we may admit that the quantity of reflected heat, lost for measuring, is perceptibly nil.

The use of our actinometer is of the simplest. Designate by V the volume of liquid (bisulphide of carbon) which condenses in a time T in the glass tube, by Δ its density at zero, by Q the quantity of heat absorbed in unit of time by unit of surface, and we have evidently

$$\frac{V\ \Delta\ q}{S\ T}=Q+c,$$

q being the total heat of evaporation, and c being the correction relating to the quantities of heat, which the apparatus loses or gains on account of the difference of temperature of the cucurbit from that of the ambient air. This quantity, in any case very small, if the instrument is well exposed and if the surface of the cooler is large enough, is easy to determine each day. To do that, it is enough at a set time to cover the cucurbit properly, so as to shelter it completely from the solar rays, and to verify how much liquid is distilled in a given time, in these new conditions, and then at the same time observe by how much the tension of the vapor diminishes in the same time.

I think it unnecessary to enter into further details as to the employment of this apparatus. It is plain that it can serve at will to determine the quantities of heat absorbed in one minute or during a whole day.

The instrument which I have constructed and installed in my observatory works up to this time to my entire satisfaction. I will give none of the numerical results until I am assured that they are really worthy of confidence.

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LITERARY NOTES.

—Circular No. 106 of the Illinois State Board of Agriculture is a pamphlet of 180 pages, of which 20 pages are devoted to meteorological summaries for Aug. to Dec., 1883, from 26 stations.

—We are in receipt of several modest publications of the Nebraska State Weather Service. In the summary for January 32 stations are represented. This service is largely carried on by private means and its success is due to the enterprise and energy of the director, Professor S. R. Thompson.

—The latest Bulletin of the Imperial Observatory of Rio Janeiro which has reached us is that for October last. It is filled with meteorological and chronometric observations with graphic representations of the former. There were three well marked minima of pressure for Rio Janeiro in October, two only of which were accompanied with precipitation. The heaviest rainfall occurred on the 11th and 12th when the pressure was at a maximum. The most marked depression of the barometer was on the 21st, when the temperature was at a maximum, but no rain fell.

—We include in this number the translation of an article on the sunglows from the *Bulletin astronomique*, in order to show our readers the tendency of French thought on the problem. In the March number of the *American Journal of Science*, Dr. H. A. Hazen has an article on the subject, of which we are in receipt of a reprint. Dr. Hazen gives his adhesion to the aqueous-vapor theory of this phenomenon, and makes out a strong case. One point in the vapor theory is that the cause is quantitatively sufficient for the effect. The same is true of the meteoric theory while the volcanic-ash theory presents a numerical ratio between cause and effect about equal to that between a pint cup and Lake Superior.

—No. XII of the Signal Service Notes is dated 1884, and contains the special characteristics of tornadoes, with practical directions for the protection of life and property. It is a pamphlet of 19 pages of condensed and valuable matter. It is a revision of an earlier pamphlet, and contains Sergeant Finley's latest views on this destructive and enigmatical species of storms.

—The Biennial Report of the State Board of Health for Minnesota for 1881–2 is an 8vo volume of 326 pages. It contains Dr. W. H. Leonard's report on the meteorology of the state for the years covered. Eleven stations are represented, 3 of which are of the Signal Service. Twenty pages are occupied with the report, and the summaries only are given. It also contains a report on the sanitary water-survey of the state, giving the results of analysis of water from 45 wells, 4 rivers, 2 springs and 1 cistern.

—The *Boletin del Ministerio de Fomento de la Republica Mexicana* is a double sheet paper issued three times a week. The agricultural department of Mexico is charged with the interests of commerce, industry and education as well as with agriculture, and its publication is largely taken up with details concerning railroads, the production of coal, the cultivation of dunes, valuable and destructive insects, etc, but it regularly contains the hourly meteorological

observations at Mexico. In successive numbers it gives data relative to the level of the lakes near the city of Mexico, and it has lately printed the March phenological calendar for the valley of Mexico and for Michoacan. The Mexican scientists are showing signs of great activity and no longer need outside assistance in the development of the extremely interesting field entrusted to them.

—The April Pilot-Chart of the North Atlantic, issued by the U. S. hydrographic office, is a very attractive chart, filled from top to bottom with meteorological and other data graphically represented. The most notable feature is the southern extension of ice for this year, which reaches latitude 39° S. S. E. of Newfoundland. The force and direction of winds and currents, the limits of the trades, the lines of magnetic variation, and the position and character of wrecks are all represented, and we find a solitary waterspout, seen March 3d, on the field of waterspouts off Cape Hatteras.

—The *Monthly Weather Review*, for January, has reached us. It contains the essence of the many thousand reports to the Signal Service for that month, and is of course replete with information. There is hardly a line in its 29 pages which could be spared without injury and our chief regret is that fuller information could not be given of the many hundred phenomena noted. Of the 18 storm-tracks mapped and described No. XII. is unusually interesting, as it was made by the union of three lesser ones near Louisville on the 18th. On the charts of ocean storm-tracks four can be traced across the Atlantic. Several hail and many thunderstorms were reported, the latter reaching as high north as Wisconsin, the former to Maine. There were many reports of sun-glows, and earthquake shocks were felt on the 3rd in Oregon, 4th California, 18th North Carolina and New Hampshire, 27th California and 29th New Brunswick.

—A pamphlet of 35 pages on the Meteorology of Oakland, California, for 1882-83 has been published by J. B. Trembley, M. D. It contains the monthly means and extremes of the usual meteorological elements for these years, and synoptical tables of the annual means for the rain-fall extending back at Oakland to 1873, and at San Francisco to 1849. The dai y change of temperature is small, the largest for the two years being 38°. Nine pages, at the end of the pamphlet, are devoted to a consideration of the modifying causes of the climate on the Pacific coast. Dr. Trembley is the chairman of the meteorological committee of the Alameda Co. Medical Association and presents a yearly report to that society. There is a striking difference in the autumns of California and the Eastern States. Autumn there is not the *fall* (fall of the leaf), but *spring* (springing of vegetation.) This difference is commented on in a brief dissertation from Dr. Trembley.

—That the French do not look on "timeliness" in the same way as does the *Academy* in a recent number is seen in that interesting and popular series of small books called "Actualites scientifiques" of which F. W. Christern, of New York, places in our hand a recent number entitled "*La Meteorologie Nouvelle.*" The author is M. R. Radau whose numerous writings show that he possesses the rare combination of a competent scientific knowledge, an unusually agreeable style and a willingness to popularize. This book is a duodecimo of 114 pages. Its first 30 pages are devoted to a review of the history of modern meteorological prediction, in which the present state of the Signal Service is sympathetically described, but the American credit in the establishment is not entirely satisfactorily set forth. On this follows a review of the current theories of storms. A second part, of 25 pages, is devoted to the studies recently made at Montsouris of what is here happily called atmospheric micorography. We commend the book to all who can use the French language, and recommend it as a model for those contemplating popular meteorological writings in English.

—To Mr. Christern also we owe a copy of *L'Annee scientifique et industrielle*, of Louis Figuier, for 1883. It is a book of 522 pages, with numerous general divisions, as Astronomy, Meteorology, Physics, Agriculture, Scientific Travels, Public Hygiene. Under Meteorology we have a brief and insufficient reference to our tornadoes, and notes on the magnetic storm at Cape Horn, Nov. 17th, 1882, a sulphurous fog at Dijon, Symons' mode of observing fogs, hail in Switzerland, fires from lightning, Lemstrom's auroral experiments, the future meteorological observatory in the Cevennes, and some other topics, all occupying 24 pages. Elsewhere is an account of the earthquake at Ischia and a brief reference to the catastrophe at Krakatoa, also to the eruption of Etna, with some other similar phenomena. As a popular annual the book is praiseworthy. That it is popular is shown by the fact that this issue is the twenty-seventh. It certainly has one characteristic usually lacking in such annuals—it is entertaining.

—Neumeyer Charts, new series. The first set of a new series of meteorological charts has just been issued from Hamburg, Germany. These charts show atmospheric conditions over the North Atlantic and portions of America and Europe. A similar series was begun in Sept. 1873, but was discontinued in Nov. 1876, and is now begun again for Dec. 1880. They are to be had only by subscription at 45 marks, ($11.25), per year.

These charts are drawn for a study of storms over the Atlantic. They contain in addition to isobars, wind-directions and velocities, a figu e at each point of observation indicating the pressure at that point and an additional figure gives the air temperature, thus avoiding the confu-

sion incident upon too many lines. The maps are to be issued in quarterly parts, and at the end of each quarter there are given mean isobars for each month of the quarter. These are hardly satisfactory for the high western part of the United States, but are an important addition to the daily charts for the rest of the region covered.

It should be noted that the observations in general are taken at about 7 a. m., local time, except in the United States, where they are taken at 7 a. m., Washington time. This may be regarded an advantage as respects the temperature, because if taken at 7 a. m., Washington time, the diurnal range causes a maximum reading of temperature on the meridian about 2½ hours east of Greenwich, and a minimum on the meridian 7 hours west. This difference amounts in many instances to 30° or more. If the pressure be considered, however, undoubtedly observations at the same moment are better. In this case the diurnal range is small, but the movement of storms would be large within the limits of the chart. This effect, however, would be slight at neighboring places and these are the ones at which comparisons are made. The conversion of the kilometer scale to English units has been done very singularly, into the geographical not statute mile. The maps are very creditable and a most valuable addition to our store of knowledge in meteorology.

H. A. H.

PARADOXERS.

THE DENSE WATER OF THE OCEAN; ITS RIVERS AND ITS CURRENTS. Lewis H. Beebe. 8o. 8 pp. Published by the author and dedicated to the people of Battle Creek.

We place Mr. Beebe in the list for which De Morgan has invented a suitable name. We know the author to be a thoughtful and honest inquirer after truth and to be full of novel ideas especially in hydrodynamics. But this sea is a dangerous one to navigate, and one must either hug the shore of ascertained facts, or, if he will plunge boldly into open water, he must trust to mathematical analysis. Mr. Bekbe has done neither, and we think he has lost his reckoning; at least we lost ours entirely in trying to follow him.

His conception seems to be a well-defined uniform mass of dense water occupying the entire ocean except surface-basins in the antarctic, arctic and two tropical regions. In the basins occur the flow and counterflow of less dense water, which also to some extent breaks through the rim of the basins, or overflows on the equatorial Atlantic rim. With these hypotheses, with an arbitrary employment of terrestrial magnetism peculiar to himself, and the employment of defining adjectives in special senses (as compensative, formative, transformative currents, and primitive motion) which he does not clearly define, he attempts to account for the oceanic circulation, hurricanes, rainy seas, precession and nutation, and throws in many suggestions concerning the asteroids, the moon, axial rotations, the "focus of the sun's apparent orbit," the eccentricity of the orbit of the earth, and many other things. Together it forms a maze through which we defy any one to follow him.

The first edition is dated Nov. 1883, and it has been followed by a second dated Feb. 1884.

THE NAVEL OF THE EARTH. BOSTON UNIVERSITY YEAR BOOK, 1884.

This article occupies a novel place in that it is inserted in the annual catalogue or calendar of an educational institution. In inserting it here, and a series of similar articles in previous year-books, the President of Boston University may be considered as following a German custom. But its place is not its only novelty. The paradoxical character of its matter and the ponderosity of its manner, join with the place of its publication to make it unique, and this uniqueness is not lessened by its title.

Dr. Warren, (in whose name the copyright of the article runs), tries to show that the north pole was the seat of Eden. The argument in that part of the treatise included in this year-book (for this is but one part of twenty) runs about like this, as we understand it: Many people have located a navel of the earth in many places, sometimes northward; the navel of the sky is the pole-star, hence the navel of the earth is the north pole. The navel of the earth has symbolical meanings attached to it, hence it was the terrestrial paradise; hence the north pole was the terrestrial paradise. Q. E. D.

This argument has the advantage of an extreme simplicity which is not concealed by the numerous learned quotations and extremely numerous references to a great number of languages both ancient and modern. But the argument is not only simple, it is picturesque. The idea of the earth rotating around its navel certainly belongs in the catagory of the picturesque, and this effect is heightened when we find the author identifying with the navel the holy mountain of Meru and the Japanese pillar on which the first soul of the earth mounted to the sky. The navel is therefore a protuberant one and it (apparently its form) is symbolized by the stupendous pyramid-temple of Cholula. In medicine we believe a protuberant navel is considered a disfigurement, but we know no reason, *a priori*, why the navel of the earth should not be protuberant.

While we do not feel competent to criticise the antiquarian learning with which these

simple though picturesque ideas are built up, yet some objections to the theory occur to us. The Bible describes the Garden of Eden as to the eastward, but the pole is always to the northward. The Bible, too, tells us that four rivers originated near the garden, and for two of these rivers, the Euphrates and Tigris, the identification seems complete, but they are not polar rivers. From the same source we learn that Cain dwelt east of Eden, but there is no east to the pole, there all is south. Besides, as meteorologists, we must call attention to the fact that the climate of the north pole is somewhat severe, and according to all narratives known to us the climate of Eden must have been mild. In geological ages as distant as the tertiary, the climate there was undoubtedly mild but would Dr. Warren place the origin of man in that distant period? If he will he has unusual courage, both from the scientific and from the theological point of view.

But we could get around all difficulties, were it not for the protubrence of the navel. If it were as other navels usually are, we could identify it with Sims' Hole, which, as its inventor proved satisfactorily to himself, occupies the surface where the north pole is usually located. Sims considered the earth as perforated, but he had never been inside, and we may grant, for argument's sake, that in this point he was mistaken, the more so as no one had ever been through the hole. We might then consider the navel imperforate and in that case, by locating Eden at its bottom, giving it what topography we pleased, arranging the atmosphere at the edge of the navel so as to properly reflect the light and heat, and granting that the myth of Daedalus represents symbolically the departure therefrom, we could easily dispose of all difficulties. In such a locality, under such circumstances, the climate could be made as tropical as we pleased. We could have all the points of the compass, and no one could dispute the topography.

BRIEF MENTION.

Scott's Elementary Meteorology has been translated into German.

The scientific results of Nordenskiöld's Vega expedition are to form a separate publication which will serve as a scientific supplement to what is already published. The contents will consist of independent articles by various members of the expedition. Among those announced for the first volume are: The auroras during the winter of 1878-79 in Behring Straits, by H. Nordenskiöld, the geographical positions determined on the expedition, by H. Lindhazen, and the meteorolocical observations, by H. Hildebrandson. There will be 12 parts at 2 marks, (50 cents), per part, to be published by Brockhaus, of Leipzig.

Among foreign books recently announced we note:

Boguslawski, G. v., Handbuch der Ozeanographie. 1 Band. Räumliche, physikalische und chemische Beschaffenheit der Ozeane. Mit 15 Abbildungen. gr. 8. Stuttgart. 417 pp.

Broszus, J. E., Die Theorie der Sonnenflecken. Nach den neuesten wissenschaftlichen Forschungen dargestellt. Berlin, 1884. Springer, 8. VII. 104 pp.

Frazio, Eng. Il diboscamento e la meteorologia. Napoli, 1883. 16. 48 pp.

Linzar, J., Anleitung zur Messung und Berechnung der Elemente des Erdmagnetismns. gr. 8. Wien. 79 pp.

Palmieri, L., die atmosphärische Elektricität. Mit Zustimmung des Verfassers aus dem Italienischen von H. Discher übersetzt. Mit 8 Abbildungen. 8. Wien. 53 pp.

Rolle, F., die hypothetischen Organismenreste in Meteoriten. gr. 8. Wiesbaden. 16 pp.

Serpieri, A., das elektrische Potential oder Grundzüge der Elektrostatik. Die neuere Theorie der elektrischen Erscheinungen in elementarer Darstellung. Aus dem Italienischen in's Deutsche übertragen von R. v. Reichenbach. Autorisirte Ausgabe. Mit 44 Abbildungen. gr. 8. Wien. 255 pp.

Mr. F. W. Christern, to whom we owe two books noticed elsewhere, has had more than a score of years experience as importer of foreign books. He has furnished periodicals to the library of the University of Michigan since its establishment, to its entire satisfaction. His address is No. 37 Twenty-third St., New York.

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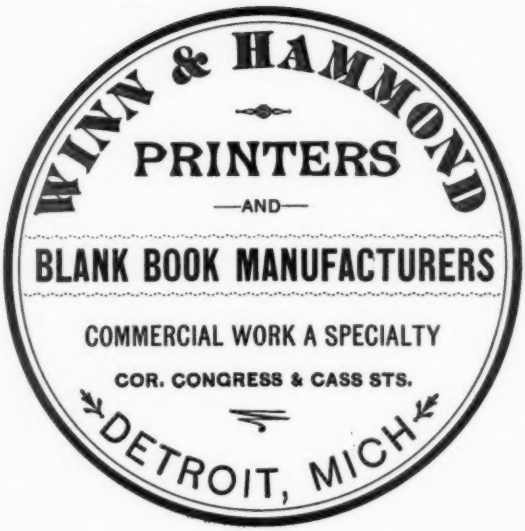
Martel's Antiquarian Catalogue, No. 77, contains several things of interest to American meteorologists. It can be obtained gratis from B. Westermann & Co., New York.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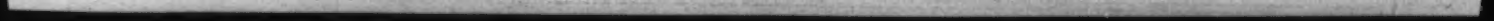

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